MORKRUM SYSTEM OF PRINTING TELEGRAPHY

BY

R. H. EARLE

ARMOUR INSTITUTE OF TECHNOLOGY

1917

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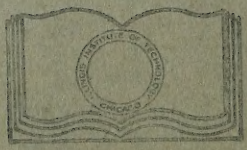

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The Morkrum system of
printing telegraphy

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

A THESIS

PRESENTED BY

RALPH H. EARLE

TO THE

PRESIDENT AND FACULTY

OF

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE OF

BACHELOR OF SCIENCE

IN

ELECTRICAL ENGINEERING

MAY 31, 1917

APPROVED:

E. H. Freeman
Professor of Electrical Engineering

H. M. Raymond
Dean of Engineering Studies

L. C. Morin
Dean of Cultural Studies

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OBJECT.

The object of this thesis is the composition of a detailed description of the Morkrum System of Printing Telegraphy.

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R.H.E.

THE MORKRUM SYSTEM OF FINISHING TEETH.

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Part I - Introductory.

GENERAL. In the operation of the Morkrum System of Printing Telegraphy, the message to be transmitted is first transcribed onto a perforated paper tape according to a code of perforations. This operation is performed on a keyboard perferator, just as though the message were being typewritten. The tape is then run through an automatic transmitter. This device, termed the transmitting distributor, sends out a series of electrical impulses over the line; the character of these impulses is determined by the perforations in the tape.

At the receiving station, the line impulses enter an automatic receiver, called the receiving distributor. Through the agency of this distributor, the incoming impulses control a series of receiving relays, which relays, in turn, control the action of a printing device. This printer is an automatic type-

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writer which prints, or typewrites, the message onto a standard message blank.

Printing telegraph systems in general possess distinct advantages over Morse systems, especially on heavy traffic lines. Printing telegraphs do not demand the services of skilled operators, whereas Morse systems are entirely dependent upon such services. This circumstance is becoming more and more important by reason of the growing scarcity of Morse operators and the consequent increase in wages demanded by them. Furthermore, the printing telegraph is able to maintain for the entire day, a speed of transmission somewhat greater then the maximum speed obtainable by manual operation. Consequently, fuller service from the equipment as well as a decrease in operating costs is gained when a printing system is

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Printing telegraph systems in

onto a standard message blank.

matter which prints, or typewrites, the message

substituted for Morse.

Before taking up a detailed study of the Morkrum System of Printing Telegraphy, we must establish the principle upon which the line signals are transmitted. This operation is performed by the machines before referred to as distributors. In order that their operation may be clearly understood, a simple device will be chosen which possesses certain features in common with the distributors. This device will gradually be developed until it finally embodies the main features of the actual distributing apparatus. After this preliminary treatment, we can take up a study of the Morkrum System in its practical form.

PRELIMINARY SYSTEM. Certain of the underlying principles of the Morkrum System of Printing Telegraphy are embodied

substituted for Morse.

Before taking up a detailed study of the Morkrum System of Printing Telegraphy, we must establish the principle upon which the line signals are transmitted. This operation is performed by the machines before referred to as distributors. In order that their operation may be clearly understood, a simple device will be chosen which possesses certain features in common with the distributors. This device will gradually be developed until it finally embodies the main features of the actual distributing apparatus. After this preliminary treatment, we can take up a study of the Morkrum System in its practical form.

of the underlying principles of the Morkrum System of Printing Telegraphy are embodied

in the telegraphic scheme of Fig. 1. D and D' are two stationary wooden disks or bases, fitted with bearings at their centers. A shaft, S, runs in these bearings, and at each end of the shaft is mounted a metal brush arm, A. These brush arms are in the same angular positions with respect to the shaft; in other words, they are in line. At its outer end, each arm carries a brush, which trails or wipes over its disk when the shaft is revolved. On each disk, and in the path of the brush, is located a series of five contact buttons, these contacts being similarly placed on each disk. Since the spacing of the arms and contacts on each disk are the same, the two brushes will always make contact with corresponding buttons. For example, if the brush at the left rests on the top contact, 1, the brush on the right will rest on the top contact, 1, at that end of

THE NORMAN SYSTEM OF TRANSMITTING TELEGRAPHY

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the shaft.

As for the electrical arrangement, at the transmitting station the contact buttons,1, 2, 3, 4, and 5, are connected respectively to the keys, K_1, K_2, K_3, K_4, and K_5, thence through the battery, B, to ground at G. Therefore, when a key is depressed, the corresponding button will be connected to the battery. At the receiving station, each of the buttons is connected through its own relay to ground at G'.

The operation of the apparatus is as follows: Rotate the shaft, S, by some means in the direction indicated by the arrow. The brushes will then wipe over the buttons in the order 1, 2, 3, 4, 5, 1, 2, ---. Therefore, if key K_1 be depressed, the negative side of the battery will be connected to button 1, and while the transmitting brush is

THE MORRUM STATUE OF FIGHTING MERMEN

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The operation of the apparatus is as follows: Rotate the shaft, 3, by some means in the direction indicated by the arrow. The brushes will then wipe over the buttons in the order 1, 2, 3, 4, 5, 1, 2, ---. Therefore, if key K_1 be depressed, the negative side of the battery will be connected to brush 1. And while the transmitting brush is

passing over the button, a circuit will be completed through the shaft, S, contact button 1 on the receiver disk, through the relay R_1, to ground at G', and thence to battery, B. The resultant current will operate relay R_1. Likewise, if any other key or combination of keys be depressed, the corresponding relays will be operated at the receiving end.

One method of carrying on communication with this device would be to arrange a code, assigning a combination of key-depressions (or relay movements) to each desired character or letter of the alphabet. In all, thirty-one combinations might thus be obtained. One complete combination or letter would be sent out for each revolution of the shaft. By depressing a different set of keys for each revolution, we could send out the successive

ONE MORAHAN SYSTEM OF PRINTING TELEGRAPH

passing over the button, a circuit will be completed through the sheet, S, contact button I on the receiver disk, through the relay R', to ground at G', and thence to button B. The resultant current will operate relay R. Likewise, if any other key or combination of keys be depressed, the corresponding relays will be operated at the receiving end.

One method of carrying on communication with this device would be to arrange a code, assigning a combination of key-depressions (or relay movements) to each desired character or letter of the alphabet. In all, thirty-one combinations might thus be obtained. One complete combination or letter would be sent out for each revolution of the sheet. By depressing a different set of keys for each revolution, we could send out two successive

letters of a word or message, and an observer at the receiving end could read off the message by the relay movements.

The system just described is of course impractical because it is necessary to connect the two stations by the shaft, S. Fig.2, however, illustrates a plan without this defect.

SECOND SYSTEM. In this second scheme, the two brush arms are not on the same shaft, but are rotated in unison by separate driving mechanisms not shown in Fig. 2. The electrical connection between the two points is maintained by the wire marked "Line", which may be an ordinary telegraph line. Hence, we may have the transmission of signals over a considerable distance.

Messages are transmitted in this scheme in exactly the same manner as in

THE MORSHOW SYSTEM OF SIGNALING UNDERWATER

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A great improvement in the scheme of Fig. 2 would be effected if some other means of transmission were used instead of the five keys; these keys are too slow and cumbersome. Consequently, an automatic transmitter has been devised and applied to the system; the new system appears in Fig. 3.

THIRD SYSTEM. In the scheme of Fig. 3, the contacts and vertical contact pins, 1, 2, 3, 4, and 5, have been substituted for the corresponding keys of Fig. 2. These pins are mounted loosely, near their ends, on a common horizontal shaft or fulcrum, and have a lever action, through a small range, about

THE MOTORUM SYSTEM OF PRINTING PHOTOGRAPHY

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this shaft. The contact is made at one end of the lever, so that a slight movement of the other end makes or breaks the contact.

The movement of the levers, with the consequent opening and closing of the contacts, is effected by means of a perforated paper tape. This tape is pulled along flatways under the free ends of the pins. At intervals, holes are punched in the tape, and when one of these holes comes under a pin, the end of the pin drops through the hole. This movement of the pin or lever closes the contact; this condition corresponds to a closed key in Fig. 2. The tape must move along at such a speed, that the combinations of contacts, corresponding to the individual letters, are maintained throughout a complete revolution of the brush arm. That is, there is always a definite relation between the speed of the tape and the speed

THE MORSE SYSTEM OF KEEPING UNDERWAYS

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The movement of the levers, with the consequent opening and closing of the contacts, is effected by means of a perforated paper tape. This tape is pulled along fastways under the free ends of the pins. At intervals, holes are punched in the tape, and when one of these holes comes under a pin, the end of the pin drops through the hole. This movement of the pin or lever closes the contact: this condition corresponds to a closed key in Fig. 2. The tape must move along at such a speed, that the combinations of contacts, corresponding to the individual letters, are maintained

tion between the speed of the tape and the speed

of the brush arm. If the tape is punched properly, line impulses corresponding to a message can be sent out.

Furthermore, the rate of transmission can be increased over the rate of the old system by the operator raising the speed of the tape, and at the same time raising the speed of the brusharms in the proper proportion. By these means, any transmission speed is obtainable, ranging from zero to seventy-five or more words per minute.

However, the rapid transmission made possible by the tape control introduces a new and serious problem, viz., the distortion of the line impulse. This distortion is carried to such an extent that inaccurate receiving is the result. This matter of distortion can be better understood, and a solution devised, through a study of a series of current impulses; we will, therefore, now take up such a study.

THE MAXIMUM SPEEDS OF MEASURING INSTRUMENTS

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THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

CURRENT IMPULSES. A series of ideal current impulses is represented in diagram (a). Such impulses occur only under perfect operating conditions. This particular series would be sent out by the transmitter during one revolution of the brush arm, with pins 1, 2, 4, and 5, in the closed contact position, and contact 3 open.

In an analysis of the diagram, assume a certain instant, 0, from which to measure time. After a fraction of a second, represented by the length Ot_1, the transmitter brush strikes button No. 1; since pin contact 1 is connected to the battery and is closed, the button is connected to the battery. Immediately, the line current rises to its full value, I_1, shown as the distance OI_1, and it maintains this value throughout the duration of contact. At the instant t_2, the transmitter brush leaves

THE MORSE SYSTEM OF PRINTING TELEGRAPHY

DAMPED IMPULSES. A series of ideal current impulses is represented in diagram (a). Such impulses occur only under perfect operating conditions. This particular series would be sent out by the transmitter during one revolution of the brush arm, with pins 1, 2, 4, and 8, in the closed contact position, and contact 3 open.

In an analysis of the diagram, assume a certain instant, 0, from which to measure time. After a fraction of a second, represented by the length $0t_f$, the transmitter brush strikes button No. 1; since pin contact 1 is connected to the battery and is closed, the button is connected to the battery. Immediately, the line current rises to its full value, I, shown as the distance $0I$, and it maintains this value throughout the duration of contact. At the instant t_g, the transmitter brush leaves

the button, and the current immediately falls to zero. This time of contact, represented by t_1t_2, is called a marking interval, and during this entire time, an impulse is being sent out over the line.

As for the succeeding periods, t_2-t_3 indicates the time necessary for the brush to go from one button to the next. The space t_3-t_4 stands for the time of brush passage over the second button; it is a marking or pulse interval, since the second pin contact is assumed to be closed and its contact button energized. Next, t_4-t_5 is the intermediate space between the second and third contact buttons.

The next interval, however, is different from any of the preceding ones. During this time, t_5-t_6, the brush is passing over the third button. It will be remembered that the third pin contact was assumed to be open; hence, the third button is not connected to

the button, and the current immediately falls to zero. This time of contact, represented by t_2, is called a working interval, and during this entire time, an impulse is being sent out over the line.

As for the succeeding periods, t_3-t_5 indicates the time necessary for the brush to go from one button to the next. The space t_3-t_4 stands for the time of brush passage over the second button; it is a marking or pulse interval, since the second pin contact is assumed to be closed and its contact button energized. Next, t_4-t_5 is the intermediate space between the second and third contact buttons.

The next interval, however, is different from any of the preceding ones. During this time, t_5-t_6, the brush is passing over the third button. It will be remembered that the third pin contact was assumed to be open; hence, the third button is not connected to

the battery; therefore, no current or line impulse appears during this interval. This is known as a spacing interval, as opposed to marking interval.

Following this period are the two marking intervals as shown, properly spaced and in every way similar to the first two marking intervals.

A series of impulses such as these is desirable in every respect. The marking and spacing intervals are regular and sharply defined; the current always assumes the same value for each pulse.A properly constructed receiver should respond perfectly to such signals.

However, it is not practical nor even possible to produce such impulses under actual operating conditions. Instead, the series takes the shape indicated in (b). Here, the sharply defined impulses of (a) become wavey, with rounded corners and no

THE MECHANISM SYSTEM OF MARKING TEMPERATURE

definite line between succeeding pulses. The middle or spacing interval is bridged over so that it appears as a weak marking pulse. Or, the pulses may be still further distorted and assume the form of those shown in (c); this latter, in fact, more nearly represents the true form of the working pulses.

As for the causes of this distortion of the impulses, there are two principal ones. The change from the regular impulses shown in (a) to the wavey form shown in (b) is caused by the phenomenom known as current lag. In brief, due to the inductance of the telegraph circuit, the line current does not rise to its full value the instant the circuit is closed by the brush arm contact. Instead, it rises gradually, requiring a very appreciable time to reach its full value. This time of rise for the first impulse is shown as t_1-t_2 in (b). In the same way, the current does

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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not fall to zero the instant the transmitting brush leaves a contact button, but, on account of the capacity of the line, requires an appreciable time to do so. This time of fall is shown as t_3-t_4 in (b). Thus, the current does not obey the makes and breaks of the circuit immediately, but is said to lag. When the impulses follow each other rapidly, one does not die away before another begins. The result is that the impulses run together; two marking intervals, separated by a spacing interval, often do this, thereby obliterating the spacing interval.

The saw-tooth form of the wave, as shown in (c), is caused by induction. The neighboring telegrapg wires induce small varying currents in the line, so that the resulting current, made up of the induced and working currents, is of the irregular form shown. The induced currents have the

THE MORSE ALPHABET OF PRINTING TELEGRAPHY

greatest effect during the early growth of the impulse; they may even be large enough to reverse the direction of the line current while the impulse is till very small. When the impulse has grown to a reasonable size, the induced currents are absorbed.

A consideration of the causes of distortion will shown that since current lag and induction increase nearly directly with an increase in length of line, the amount of distortion varies nearly directly with the length of line.

The effect of impulse distortion on accurate receiving of signals is apparent. Not only does confusion result from the bridging over of the spacing intervals, but also from the fact that the receiver lags behind the transmitter. This lag occurs because the receiver does not respond until the impulse has grown to a working

THE MINIMUM SYSTEM OF RADIATING TRANSMITTER

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value. The induced currents do not, as a rule, reach sufficient magnitude to operate the receiving relays; their usual effect is to distort the impulse by destroying the early part, and thereby still further retard the receiver. Since the amount of distortion depends upon the length of line, the longer the line is, the more difficult becomes operation; satisfactory operation cannot be maintained over lines of any practical length.

With the underlying causes of distortion in mind, we are now prepared to take up the solution of the problem. A study of the impulse diagram will show that the question becomes one of causing the impulses to grow to their final working value very rapidly. If the impulses should rise quickly, they would not tend to spread out

THE NYQUIST SYSTEM OF TESTING TELEGRAPHY

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so much, so that there would be a sharp dividing line between marking and spacing intervals. Furthermore, the effect of the induced currents would be minimized, since their greatest effect occurs during the early growth of the pulse, which period would be short.

The solution which has given the most satisfaction is what is known as double current operation. In this scheme, there is a marking pulse as before. However, instead of a space interval being indicated by a current pulse of no magnitude, that is, by an absence of current, it is indicated by a current pulse in the opposite direction. For convenience, the spacing pulse is called positive, whereas the marking pulse is called negative. The terms positive and negative merely indicate that the line currents are

THE MORSE SYSTEM OF PRINTING TELEGRAPHY

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opposite directions in the two cases. The use of both marking and spacing impulses of course necessitates some changes in the equipment, but these changes will be taken up a little later.

The reason for the more satisfactory operation of the double current system can be more clearly understood after that explanation of certain principles of current rise in a circuit. It was just shown how, when there is current in a circuit, the current lags or falls to zero gradually when the circuit is opened. If an e.m.f. be applied, opposite in direction to the one which established the current, the current will fall much quicker than it otherwise would. If the e.m.f. be maintained, the current will decrease, pass through zero, and build up in the other direction.

THE MORRUM SYSTEM OF SIGNALING (CONTINUED)

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to illustrate the application of this principle to our own problem, consider the same impulse series as was used in the previous discussion, except with both marking and spacing pulses. The intervals of this series are marking, marking, spacing, marking, marking, or, in terms of current direction, negative, negative, positive, negative, negative. This series is pictured in (d).

An observation of diagram (d) shows that the two negative or marking pulses which come first are the same as in diagram (c). But at the beginning of the third or spacing interval, a positive e.m.f. is applied, which action causes the line current to fall almost instantly to zero and start to rise in the positive direction. Likewise, at the beginning of the fourth interval, which is marking, the line current quickly reverses and builds up in the negative direction. The last

NEW MODIFICATION OF RECTIFYING INTERRUPTER

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two intervals are marking, similar to the first two.

A further observation of the diagram shows that the marking and spacing pulses are clearly defined. Furthermore, the pulses are at high values throughout nearly all of their existance, so that the induced currents from other lines are soon absorbed. Thus, the problem of producing definite pulses, little affected by induced currents, is apparently solved.

FOURTH SYSTEM. The application of the principle of double current operation to the telegraphic system which was developed earlier in this discussion appears in Fig. 4. However, before the system as a whole is explained, two new pieces of apparatus should be described.

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is a relay pole changer. This is an ordinary relay equipped with both front and back contacts. When the relay coil is not energized, the armature remains against the back contact, but when the coil is energized, the armature is drawn forward against the front contact.

The other new device is a polarized relay. This relay has an armature which plays between two contacts, but has no retractile spring. When the coils of the relay carry current in one direction, the armature takes position against one contact. If the coil current is reversed, the armature goes over to the other contact. Since there is no retractile spring, when there is no current in the coils, the armature remains against whichever contact it happens to be.

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planation of the new scheme. As in the preceding system, there are the tape contacts. These contacts do not, in this case, control the line impulses directly, but do so through five of the relay pole changers just described, one pole changer being provided for each of the five tape contacts. Each set of relay coils is connected to the local battery by means of its own tape contact, so that when the contact is open, the relay is not energized and the armature remains against the back point; when the tape contact is closed, the relay is energized so that the armature is drawn over to the front point. The current path from the back point of the relay pole changer is to the negative side of the marking battery and through the battery to ground. The front contact is connected to the positive side of the spacing battery, the negative side

THE NORMAN SYSTEM OF SIGNALING ILLUSTRATED

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The front contact is connected to the positive
side of the signal battery, the negative side

of which goes to ground. The armature is connected to one contact button of the transmitting disk. The revolving brush arm is connected to the line.

A consideration of the transmitter circuit shows that with a tape contact open, a negative or marking line impulse is sent out, and with a tape contact closed, a positive or spacing impulse is sent out. Thus, the tape contacts control the character of the line impulses.

At the receiving station, the line is connected through the operating coils of a polarized relay to ground. Therefore, a positive current pulse throws the armature to one side or point, whereas a negative pulse throws the armature to the other point. One point is dead, the other point is connected to one side of the local battery, and the ar-

THE MORSE SYSTEM OF SIGNALING TELEGRAPH

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mature is connected to the receiver brush arm. The receiver relays are connected between their respective control buttons and the free side of the local battery.

As for the operation of the receiving apparatus, suppose a spacing or positive line impulse appears. The armature of the polarized relay goes to its dead contact, so that no local relay is affected. Suppose a negative or marking interval next appears. The armature of the polarized relay goes over to the opposite point, which is connected to the battery. The local relay is energized, and indicates a signal. Thus, in this system, the local receiving relays respond only to the marking intervals, just as was the case in the former system.

FIFTH SYSTEM. Fig. 5 shows a still further development of the system. This

THE COMMON SYSTEM OF SIGNALING DESCRIBED

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scheme is the same as that of Fig. 4, except that the line signals are sent out by a main-line pole changer, controlled by the relay pole changers, instead of being sent out by the relay pole changers themselves. This main line pole changer is merely a polarized relay with its operating coils connected to the battery through the relay pole changer contacts, its armature connected to the line, and its two points connected respectively to the spacing and marking batteries. The other sides of the batteries are grounded. The operation of the system is apparent from the diagram.

This system possesses two advantages over the former one. The first is that the number of contacts in the main line circuit is reduced to one, viz., the one at the main line polechanger. Under adverse conditions of operation, this feature is of no

THE MORKUM SYSTEM OF SIGNALING DURING LIGHT

scheme is the same as that of Fig. 1, except that the line signals are sent out by a main-line pole changer, controlled by the relay pole changer, instead of being sent out by the relay pole changer themselves. This main line pole changer is merely a polarized relay with its operating coils connected to the battery through the relay pole changer contacts, the armature connected to the line, and the two points connected respectively to the opposing and mounting batteries. The other sides of the batteries are grounded. The operation of the system is apparent from the diagram.

This system possesses two advantages over the former one. The first is that the number of contacts in the main line circuit is reduced to one, viz., the one at the main line polesmember. Under adverse conditions of operation, this feature is of no

little importance.

The other improvement appears when a number of marking or of spacing intervals are transmitted in succession. The main-line-pole-changer armature retains the same position throughout the series; hence, the line current is maintained constant at its full value throughout the series. Current lag therefore does not occur except when successive impulses are of different signs.

SIXTH SYSTEM. The final development of the system is shown in Fig. 6. The scheme of Fig. 6 is the same as that of Fig. 5 except for two changes in the receiving apparatus. These changes still further decrease the possibilities of wrong interpretation of the incoming impulses by the receiving apparatus.

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THE MINIMUM AMOUNT OF PRINTING TECHNOLOGY

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[illegible]. The third development of the system is shown in Fig. 6. The scheme of Fig. 6 is the same as that of Fig. 5 except for two changes in the receiving [illegible]. These changes still further decrease the possibilities of wrong interpretation of the incoming impulses by the receiving repeaters.

The first change is the fact

that the receiving polarized relay does not control the five simple relays directly, but instead, controls an exactly similar polarized relay, which, in turn, controls the five simple relays. This working is plain from Fig. 6.

The second change is shown schematically. It consists of an adjustment by which the receiver disk can be moved forward in the direction of rotation of the brush arm, or can be retarded against the direction of rotation of the brush arm. The total angle through which the disk may be turned is perhaps forty degrees.

The reason for this modification may best be studied from Diagram (e). This diagram is the same as (d) as far as the wave form of the impulse is concerned. It will be noticed from the diagrams that the

THE MODERN SYSTEM OF RECEIVING TELEGRAPHY

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simple relays. This working is plain when used relay, which, in turn, controls the five instead, controls an exactly similar polar- ized relay. It controls the five current the five simple relays directly, but that the receiving polarized relay does not

impulses are quite jagged and irregular. The irregularities may produce a slight fluttering of the armature of the receiving polarized relay, especially near the transition period between positive and negative pulses. This fluttering is not of sufficient magnitude to throw the armature from one point to the other, but it is great enough to produce a poor contact. Such a contact would not be desirable in the circuit of the simple relays.

A remedy for the uncertain contact in the circuit of the five relays is provided when the second polarized relay is added to the scheme of Fig. 5. This relay does not change its position unless the main line relay first changes; any fluctuation of the armature of the main line relay less than a complete movement from one point to

than a complete movement from one point to the armature of the main line relay less line relay first energized, any fluctuation does not change its position unless the main lead to the volume of Fig. 5. This relay provided when the second polarized relay is contact in the circuit of the line relays is a remedy for the uncertain

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the other does not affect the second relay. The armature of the second relay possesses sufficient residual magnetism so that the contact is kept firm. Hence, any flutterings of the main-line-relay armature do not affect the local relays.

The impulses in the local circuit, with the plan just described, are shown by the rectangular full-line pulses in (e). The transmitted pulses are shown dotted. It will be noticed that the received pulses are fair reconstructions of the transmitted pulses, but occur at a slightly later time because of current lag.

The second change in the system, viz., the angular adjustment of the receiver disk, allows the middle, or fullest portion of the pulse to be utilized. This fact may be understood by a reference to (e).

THE MODERN SYSTEM OF PRINTING TELEGRAPH

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THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

This diagram shows the pulses, and also shows the buttons of the receiver disk developed, or rolled out, just below. The buttons are drawn in to such a scale that the diameter of each button represents the time of brush-passage over that button, and the distance between buttons represents the time required by the brush to pass from one button to the next. The buttons are small compared to the pulses, and that portion of the pulse lying directly above each button is the only portion utilized; the remainder of the pulse occurs while the brush is between buttons. By sliding the entire row of buttons along under the row of impulses, we can make any button receive any part of the impulse series.

This condition can be actually duplicated in practice by the revolution of the the disk upon which the buttons are mounted. However, in practice it is never desired

THE NONSYNCHRONOUS MEASURING

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riding the entire row of buttons along under
the drum. However, in practice it is never desired
that the item upon which the buttons are mounted
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This condition can be naturally
receive only part of the impulse series.

that an impulse be received on any but its own button. Hence, the angle through which the disk turns is only sufficient as to allow each button to receive any part of its own impulse, with a little added leeway in both directions of rotation.

The results of such an adjustment of the disk are two in number. The first is that the disk can be adjusted so as to admit only the peaks of the impulses. Hence, with the aid of the two relays on the line side of the disk, greatly distorted impulses can be correctly interpreted. The second result is that on long lines, where the current lag may produce quite a lag of received pulses behind the transmitted pulses, the receiver disk can be rotated backward until the brush-and-button contact occurs at the same time as the reception of the pulse.

the same time as the reception of the pulse. If the brush-and-button contact occurs at the receiver disk can be rotated backward, saved pulses behind the transmitted pulse, current lag may produce quite a lag of resound result is that on long lines, where the pulses can be incorrectly interpreted. The side of the disk, greatly distorted impulse, with the aid of the relays on the ne as to admit only the peaks of the impulses. first is that the disk can be adjusted so justment of the disk are two in number. The

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low each button to receive any part of its the disk brush is only sufficient as to al- own button. Hence, the angle through which that an impulse be received on any but its

Another way of looking at the condition is that the two brush arms are revolving at exactly the same speed, but the receiving arm stays a little behind the transmitting arm, the distance behind depending upon the current lag.

This last described system constitutes the Morkrum System of Printing Telegraphy reduced to its simplest form. The scheme includes the essential features of the Morkrum distributors. (These are so called because they take the five character elements of position, which are found on the tape, distribute them as impulses or elements of time, and then, at the receiving station, retransform the elements back into those of position, that is, relay positions.) This distributing apparatus, together with the tape perforator and automatic printer, makes up the commercial Morkrum System.

THE MORKRUM SYSTEM OF MULTIPLEX TELEGRAPHY

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

With this preliminary survey of the plan, we are ready to take up a detailed description of the commercial system. There are a number of different types, differing in the minor details, but the one described in the following pages is the one commonly used on commercial duplex telegraph lines.

THE DUPLEXUM SYSTEM OF MULTIPLE TELEGRAPHY

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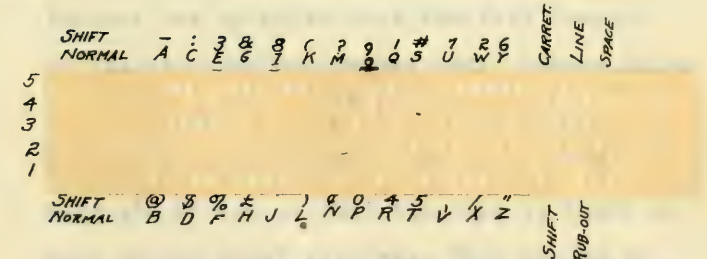
THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

Part II - Tape, Code, and Perforator.

THE TAPE. As was said before, the message to be transmitted by the Morkrum System of Printing Telegraphy is first punched onto a paper tape, the number and arrangement of punched holes depending upon the letter or character which the holes represent. Samples of the tape are shown below.



The holes for any one letter or character are arranged in a row across the tape, with the proper blank or unpunched spac-

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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es between holes. The rows are separated a distance of about one-tenth of an inch, this being sufficient to produce clear distinction between successive letters. Notice that the rows of holes are not exactly perpendicular to the length of the tape, but that they slant backward a little. The reason for this slant will be explained in connection with the transmitting distributor.

Besides the holes used in combinations to represent letters, a continuous row of holes runs the full length of the prepared or pundhed tape. Theses holes are used in feeding the tape through the apparatus. The teeth of a small spur wheel engage the holes, so that the tape is drawn along as the wheel revolves. This system of feeding affords a positive and definite tape movement; the tape cannot slip without the

THE MECHANICAL ARRANGEMENT OF PRINTING EQUIPMENT

movement: the tape cannot slip without the feeding of both a positive and definite tape long as the wheel revolves. This system of depends the holes, so that the tape is drawn perature. The teeth of a small rubber wheel engage the prepared or punched tape. Chosen holes are used in feeding the tape through the apsimulous row of holes runs the full length of the tape, but that they combinations to represent letters, a combeside will be explained in connection with the transmitting distributor.

Besides the holes used in

feed holes being torn out. If such trouble occurs, it is at once noticed by the operator and can be remedied.

THE CODE. The perforations f follow the plan of the five-unit code, which is given on the sample of tape, p.35. This is called a five-unit code because for each letter or character, there is a total of five intervals, either holes or blanks; "blank" is used for want of a better term, and denotes every location where no hole is punched. The intervals or elements are numbered for reference 1, 2, 3, 4, and 5, across the tape. The five elements allow of thirty-one combinations; hence, thirty-one characters are available. By the use of a shift, similar to a typewriter shift, thiry-one new meanings may be assigned to the combinations, so that a total of sixty-two characters or signals are available.

THE MODERN SYSTEM OF PUNCHED MECHANISM

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ence 1, 2, 3, 4, and 5, across the tape. The
intervals or elements are numbered for refer-
every location where no hole is punched. The
is used for want of a better term, and denotes
intervals, either holes or planks; "plank"
letter or character, there is a total of five
is called a five-unit code because for each
is given on the example of tape, p.85. This
follow the plan of the five-unit code, which
ITEM CODE. The perforations f
occurs, it is at once noticed by the opera-
tor and can be remedied.
face holes being torn out. If such trouble

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

Besides the actual characters which are to be transmitted and printed at the receving station, the code also includes several operating signals, which govern certain functions of the printer aside from its regular printing movements. These signals are: space, carriage return, lining, shift, and rub-out. The space signal causes a space to be left between successive words of the printed message. The carriage return is used when a new printed line is to be started. The lining signal causes the printer to turn up a new line, just as is done in the operation of a typewriter. The shift signal causes shift characters to be printed instead of the normal characters; the printing of the normal characters is restored by the space or the carriage return signal. The rub-out is used

when a mistake has been made in perforating the tape. The tape is run through the perforator again, and the erroneous letters are punched out. Note that the rub-out combination of holes is the only one comprising all five intervals; hence, any other character contains fewer holes, and can be punched out. When the printer receives the rub-out signal, it remains inoperative or "marks time" until a different signal is received; the printer then performs its usual functions, just as it did before the rub-out signal was received.

THE PERFORATOR. The tape is punched by means of a keyboard perforator. The general performance of the machine is as follows: The actual punching of the tape is done by a row of six pin punches which face a die; the tape passes between the punches and the die. Five of the punches are for the five

THE MORSE SYSTEM OF SIGNING TELEGRAMS

when a mistake has been made in perforating the tape. The tape is run through the perforator again, and the erroneous letters are punched out. Note that the run-out combination of holes is the only one comprising all five intervals; hence, any other character contains fewer holes and can be punched out. Then the printer receives the run-out signal, it remains inoperative or "marks time" until a different signal is received; the printer then performs the normal functions, just as it did before the run-out signal was received.

THE PUNCHING. The tape is punched by means of a keyboard perforator. The general performance of the machine is as follows: The actual punching of the tape is done by a row of six pin punches which face a die; the tape passes between the punches and the die. Five of the punches are for the five

code holes, whereas the sixth is for the feed holes. An electro-magnetic hammer forces the punches through the tape; on the back or return stroke of the hammer, the tape is advanced one feed hole, so that a fresh section is ready to receive the next series of perforations. Different combinations of holes are selected for the different characters by a selective mechanism worked from the keyboard. This mechanism operates as follows: Between the hammer-head and the punch pins exists a small clearance, in and out of which five rods or punch levers slide independently. One punch lever is provided for each of the five code punches, but none is provided for the feed punch. When certain holes are to be punched, the corresponding punch levers are left between the hammer head and punches, filling up the clearance. On the forward stroke

DES. CRITICAL ASPECTS OF PERFORATED MATERIALS

code holes, whereas the sixth is for the feed holes. An electro-magnetic hammer forces the punches through the tape; on the back or return stroke of the hammer, the tape is advanced one feed hole, so that a fresh section is ready to receive the next series of perforations. Different combinations of holes are selected for the different characters by a selective mechanism worked from the keyboard. This mechanism operates as follows: Between the hammer-head and the punch pins exists a small clearance, in and out of which five code or punch levers slide independently. One punch lever is provided for each of the five code punches, but none is provided for the feed punch. When certain holes are to be punched, the corresponding punch levers are left between the hammer head and punches, filling up the clearance. On the forward stroke

of the hammer, the pins are pushed through the paper. If a hole is not to be punched, the punch lever corresponding to that hole is withdrawn from the clearance between the hammer and punches; then, on the forward stroke, the hammer enters the clearance, but not far enough to strike the pin. Hence, no hole is punched by that particular pin. The feed holes are always punched; the selective mechanism has no control over the pin which punches the feed holes. The rods or punch levers are controlled through a series of levers from a keyboard, similar to that of an ordinary typewriter. The keyboard also automatically control the electro-magnetic hammer.

With the idea of the general functions of the perforator in mind, we can now take up a discussion of the machine in its

THE MECHANICAL ORGANISM OF PUNCHING MACHINERY

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practical form. In this entire discussion, rough sketches will be used to show the general construction of the parts, but these sketches are not intended to represent the apparatus in detail; the accompanying photographs of the machine show the details of construction.

GENERAL LAYOUT. The perforator consists of a hollow cast iron base, on the top of which are located the hammer and punch mechanisms and the tape reel. The keyboard overhangs the front of the base. Some of the connecting levers between the keyboard and punch pins are inside the base, whereas some are on top. Fig. 7 shows a top veiw of the perforator; the different parts are identified in the sketch.

THE PUNCH PINS. At the lower left-hand corner of the base are the punch

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THE PUNCH PINS. At the lower left-hand corner of the base are the punch

pins and die. The punches are of steel, about one-tenth inch in diameter by one and one-fourth inches long. There are five of such pins for the tape contact holes, and an additional smaller pin for the feed holes. All six pins slide back and forth in guide holes bored through the face of a small block. The idea is illustrated by Fig. 8, where B denotes the guide block. The block is ⊏-shaped, and across the open face extends a cover plate, E, also bored with guide holes for the pins. The die, D, lays over this cover plate. The two are channelled out slightly so that the tape can be drawn along between them. The pins ordinarily project behibd the back face of the block, and also extend, at their opposite ends, nearly through the end plate, E; they do not, however, extend into the tape channel. The hammer strikes the projecting

THE MORGENS SYSTEM OF PRINTING PERFORATING

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ends of the pins, and drives the pins across the channel into suitable recesses in the die; if the tape is in place between the die and end plate, it is of course punched. The punch ends of the pins are slightly hollow-ground so as to give better cutting edges.

The method of returning the pins to their original positions, on the back stroke of the hammer, is also indicated in Fig. 8. The feed-hole pin, F, is rigidly attached to a ⊢ -shaped crosshead, C, which slides back and forth in the guide block; the crosshead is normally held at the rear of the guide block by the spring, S. The forward stroke of the crosshead is limited by its lug (the stem of the "T") striking the end plate, E. The croddhead is also bored with holes for the punch pins, but the fit between the crosshead and pins is so loose

DESCRIPTION OF PLATE OF PRINTING MECHANISM

that the crosshead slides forward freely, without pulling any of the pins along with it. Each of the five pins is fitted with a small collar, which rests against the back face of the crosshead. The crosshead ordinarily bears against these collars, so that the pins are held in their extreme back position clear of the tape.

In the operation of the arrangement, after the crosshead has started on its forward stroke, any of the pins can follow, in case they too have been struck by the hammer. The crosshead stays ahead of the pins until the end of the stroke, and the pins go through a punching movement the same as though the crosshead were not present. On the back stroke, however, the crosshead strikes the collars on the pins and carries all the pins back to their original

THE MINIMUM NUMBER OF BRANCHING TRANSPOSERS

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positions. A feature which should be noticed here is that at the end of the forward stroke, the pin collars strike the crosshead, and their travel is thereby limited; otherwise, the pins would drive into the die and soon loose their cutting edges.

The method of starting the crosshead on its forward stroke is also apparent from Fig. 8. It will be remembered that the five contact-hole pins are not struck directly by the hammer, but instead, small interference rods are inserted between the hammer and the pins, so that the rods are struck by the hammer. A feed hole, on the other hand, must be punched at every stroke of the hammer, and hence no punch lever is provided for the feed pin. Instead, this pin projects beyond the others a distance slightly in excess of the thickness of a punch lev-

THE MOMENTUM SYSTEM OF PUNCHING TRIGGERING

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er. Therefore, the feed pin is struck by the hammer before any of the punch levers, so that the feed pin and crosshead lead the other pins throughout the stroke. It is apparent that with this method, the proper movement of the pins is not interfered with by the crosshead.

THE HAMMER. The hammer magnet consists of two solenoids, designed for 110 volts, direct current. The solenoids are placed horizontally at some distance behind the punch pins and in line with them. The arrangement is clear from Fig. 7. The two coils are supported from the base by a bracket, which is attached to those ends of the coils adjacent to the punch pins. The solenoids are fitted with movable cores or plungers, which slide in and out of the rear ends of the coils. A yoke connects the cores, and

from the center of this yoke, a plunger rod goes forward between the solenoids, through a guide hole in the bracket, and terminates in a round-headed nut, N. A hammer spring, acting against the magnet, normally keeps the cores drawn partially out of the coils and the plunger rod in its extreme back position. When the coils are energized, the cores are drawn into the coils, and the plunger rod thrusts forward toward the punch pins. The hammer solenoids are controlled automatically from the keyboard.

The hammer itself is a horizontal steel lever, pivoted at A (see Fig. 7), and extends into the clearance between the end of the plunger rod and the punch pins. Thus, when the plunger rod comes forward, it thrusts the hammer on ahead of itself.

The construction of the ham-

THE MORPHEUS STRUMM OF INDIANA TECHNICIANS

from the center of this yoke, a plunger rod rose forward between the solenoids, through a guide hole in the breaker, and terminates in a round-headed nut, M. A hammer spring, nothing against the hammer, normally keeps the curved drum partially out of the coils and the plunger rod in the extreme back position. When the coils are energized, the curved arm drawn into the coils, and the plunger rod thereby forward toward the piano. The hammer solenoids are controlled automatically from the keyboard.

The hammer itself is a bent-metal steel lever, pivoted at A (see Fig. 7), and extends into the clearance between the end of the plunger rod and the grand piano. Then, when the plunger rod moves forward, it thrusts the hammer on ahead of itself.

mer is shown in Fig. 9. As indicated, the hammer is channelled out along its length. The channel faces the punch pins. In line with the pins is cut the rectangular notch, B (see Figs. 7 and 9). When the end of the hammer is pushed forward by the plunger rod, the ends of the punch pins enter the notch, B. The channel and notch furnish the clearance, before referred to, between the punch pins and hammer. Note that the bearing at A, upon which the hammer is pivoted, is offset from the center-line, so that the bearing stud is well clear of the middle of the channel.

THE PUNCH LEVERS. The five interference pins or punch levers, which slide in and out of the clearance between the hammer and the punch pins, are merely square steel rods; they move lengthways of the hammer through

THE MOVEMENT OF PUNCHING MECHANISM

mon is shown in Fig. 2. As indicated, the hammer is shunnelled out along its length. To channel keeps the punch pins. In time with the pins is out the restraining rods, B (see Figs. 4 and 8). When the end of the hammer is pushed forward by the plunger rod, the ends of the punch pins enter the motor, 3. The channel and motor furnish the clearance, before referred to, between the punch pins and hammer. Note that the bearing at A, upon which the hammer is pivoted, is offset from the center-line, so that the bearing stud is well clear of the middle of the channel.

THE PUNCH DRIVER. The five interference fins on punch levers, which slide in and out of the clearance between the hammer and the punch pins, are merely cylinders about; they move lengthways of the hammer through

the channel. They are arranged in a vertical row or pile, so that each one is in the horizontal plane of a punch pin. The levers are numbered from 1 at the bottom to 5 at the top, corresponding to the same numbers of the code elements. The punch levers extend just far enough along the channel that their ends cross the notch in the channel, and thereby fill up the clearance space at the back of the pins. However, each lever may be withdrawn from the channel for about half an inch; this movement is sufficient to re-establish clearance.

SELECTIVE MECHANISM. The method of moving the punch levers from the keyboard is illustrated in the isometric sketch of Fig. 10; this sketch, for simplicity, shows the complete links for only one punch lever, and shows only one key. Each key is the terminal of a long arm, K, the back end of which

THE MORGAN SYSTEM OF SOLUTION MECHANISM

the channel. They are arranged in a vertical row or pile, so that each one is in the horizontal plane of a punch pin. The levers are numbered from 1 at the bottom to 0 at the top, corresponding to the same numbers of the code elements. The punch levers extend just far enough along the channel that their ends cross the notch in the channel, and thereby fill up the clearance space at the back of the pins. However, each lever may be withdrawn from the channel for about half an inch; this movement is sufficient to re-establish clearance.

SHUNTING MECHANISM. The mechanism of moving the punch levers from the keyboard is illustrated in the isometric sketch of Fig. 10; this sketch, for simplicity, shows only one key. Each key is the terminal of a long arm, K, the back end of which

is mounted on a shaft, S. The key lever, or arm, has a projection, P, which rests on a large rectangular strap-iron loop, L; the loop has no back side, but instead, the two ends of the strap are supported by two bearings, BB, as shown. The arm, F, is attached to one end of the loop, and rises vertically. The upper end of the arm, F, is slotted, and engages the short end of the bell crank, D. The crank has a suitable bearing at E. The long arm runs forward to the punch lever, and is pivoted to that lever at A. Tracing through the link movements, we find that if the key lever is pushed down, as it would be by the depression of a key, the front of the loop, L, is also pushed down; this movement brings the upper end of F forward, and with it, the short arm of the bell crank. The long arm of the bell crank is thereby drawn toward

THE MORSE SYSTEM IN TELEGRAPHY

is mounted on a shaft, S. The key lever, or arm, has a projection, P, which rests on a large resenmbler strap-iron loop, L; the loop has no back side, but instead, the two ends of the strap are supported by two bearings, BB, as shown. The arm, A, is attached to one end of the loop, and rises vertically. The upper end of the arm, B, is slotted, and engages the short end of the bell crank, C. The crank has a suitable bearing at B. The long arm runs forward to the finger lever, and is pivoted to that lever at X. Tracing through the link movements, we find that if the key lever is pushed down, as it would be by the depression of a key, the front of the loop, L, is also pushed down; this movement brings the upper end of F forward, and with it, the short arm of the bell crank. The long arm of the bell crank is thereby drawn toward

the right, and it pulls the punch lever with it. This movement of the punch lever is the one desired. All parts are returned to their original positions by springs, not shown in the figure. The controls for all the punch levers are the same: each punch lever has its own bell crank and loop movement.

In Fig. 11 is shown the complete selective mechanism with the exception of some of the keyboard keys and levers which are left out to simplify the sketch. The method of nesting the six loops and the arrangement of the bell cranks should be noted especially. The sketch also shows the several fingers which each key lever carries. These fingers point downward, and each rests on one of the loops; hence, the depression of a key simaltaneously depresses several loops, and, at the same time, withdraws several punch levers. By this action, a key controls such

CAM MOVEMENT AS THEY DO IN THE TELLTALE MECHANISM

the right, and it pulls the cam lever with it. This movement of the cam lever is the one described. All parts are returned to their original positions by springs, not shown in the figure. The controls for all the cam levers are the same: each cam lever has its own bell crank and loop movement.

In Fig. 11 is shown the complete selective reinsertion with the exception of some of the keyboard keys and levers which are left out to simplify the sketch. The method of meshing the cam lobes and the arrangement of the bell cranks should be noted especially. The sketch also shows the several fingers which each key lever carries. These fingers point downward, and each rests on one of the lobes; hence, the depress-

punch levers as will cause the proper holes to be punched in the tape.

The hammer control is indicated in the same figure. In addition to the five bell cranks, there is a sixth lever mounted with them and similarly controlled. This lever is the top one of the bell crank group, and is operated from the outside loop. The top lever has no long arm extending to a punch lever, but instead, consists of a single arm, identical with the short arms of the bell cranks. This arm controls the hammer magnet through the series contact shown. One point of the contact is stationary, whereas the other is carried by the lever just mentioned. The contact is normally open, but when the arm is moved forward, by a depression of the front loop, the contact closes and connects the solenoids to the source of current sup-

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ply. The contact is adjusted to close just after the punch levers have been withdrawn by the bell cranks.

As for the location and mounting of the link mechanism on the machine, the bell cranks and contact are situated nn the top of the base, as indicated in Fig. 7, whereas the loops and keylevers are inside the hollow base of the machine; the levers F of Fig. 10, connecting the loops and bell cranks, extend upward through slots of the grid, G, as indicated in Fig. 7. The mounting of the bell cranks on the vertical studs is also apparent from Fig. 7.

The method of suspending the loops and key levers in the base is illustrated in Fig. 12, which is a veiw upwards at the bottom of the machine. The six free ends of the two sides of the loops are mounted in the

THE MORRUM SYSTEM OF PRINTING TELEGRAPHY

play. The contact is adjusted to close just after the punch levers have been withdrawn by the bell cranks.

As for the location and mounting of the link mechanism on the machine, the bell cranks and contact are situated on the top of the base, as indicated in Fig. 7, whereas the loops and keylevers are inside the bottom base of the machine; the levers 2 of Fig. 10, connecting the loops and bell cranks, extend upward through slots of the grid, 6, as indicated in Fig. 7. The mounting of the bell cranks on the vertical studs is also apparent from Fig. 7.

The method of suspending the loops and key levers in the base is illustrated in Fig. 12, which is a view upwards at the bottom of the machine. The six free ends of the two sides of the loops are mounted in the

two bearings as shown. Washers or spacers are placed between adjacent straps in order that there shall be no interference between them. The loops are held up snugly against their backstop on the under side of the base by return springs. The idea is clear from Fig. 13, and needs little comment. The rod, R, of Fig. 13, runs the full length of the loops. This spring support allows the front of the loop to be pushed down by a key lever, but immediately returns the lever to its normal position when the pressure is released.

The mounting of the key levers is similar to that of the loops, and is shown in Fig. 12. The back ends of all the levers are strung loosely on a shaft, S; the levers are kept separated on the shafts by spacers. The key levers have spring returns, similar to those of the loops. All springs, both of

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the loops and key levers, are anchored to the rod, R, of Fig. 13.

THE KEYBOARD. The key levers terminate at the front of the machine, have key buttons attached to the front ends, and thereby form the keyboard. The plan of the keyboard is clear from Fig. 7. In a general way, it follows the plan of the standard typewriter keyboard, but as only upper case letters are used in telegraphic work, additional characters are supplied instead of the two separate styles of letters. Notice that besides the actual printing characters, the keys include the operating signals, such as carriage return (CARRET), lining, and others.

THE TAPE FEED. The method of feeding the tape may be seen in Fig. 7. The tape reel is normally supported horizontally on the top of the base to the right of the

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

on the top of the page to the right of the tape reel is normally employed horizontally feeding the tape may be seen in Fig. 7. The

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bell cranks. The tape unwinds from the reel, passes between the punch pins and die, and then passes between an idler or tension roller and the feed roller. The idler is pressed against the feed roller by a spring. The idler and feed roller may be seen in Fig. 7 at the left of the punch pins and die. The feed roller is a vertical cylinder, slightly higher than the tape is wide. It has projecting pins or teeth which engage the feed holes in the tape, so that the tape is pulled along as the feed roller turns. The idler is a second cylinder which serves to keep the tape close-up against the feed roller.

The driving of the feed roller is accomplished by a ratchet and pawl movement, a part of which movement may be seen in Fig. 7. At the bottom of the feed roller, and rigidly mounted with it, is a

THE MORTRUM SYSTEM OF PRINTING TELEGRAPHY

bell crank. The tape running from the reel, passes between the punch pins and die, and then passes between an idler or tension roller and the feed roller. The idler is pressed against the feed roller by a spring. The idler and feed roller may be seen in Fig. 7 at the left of the punch pins and die. The feed roller is a vertical cylinder, slightly higher than the tape is wide. It has projecting pins or teeth which engage the feed holes in the tape, so that the tape is pulled along as the feed roller turns. The idler is a second cylinder which serves to keep the tape close-up against the feed roller.

The driving of the feed roller is accomplished by a ratchet and pawl movement, a part of which movement may be seen in Fig. 7. At the bottom of the feed roller, and rigidly mounted with it, is a

ratchet wheel. A long pawl attached to the end of the hammer comes forward with the hammer on the forward stroke; the pawl hooks over a tooth on the ratchet, and on the back stroke of the hammer, pulls back the ratchet one tooth. This movement of the ratchet advances the feed roller and tape one step. These steps are about one-tenth inch long, measured on the tape, which distance is sufficient to produce clear distinction between successive letters on the tape.

The punching, feeding, and selective mechanisms, so far described, constitute the essential parts of the perforator. Experience, however, has shown the desirability of adding two more features.

THE BACK SPACER. The first of these new elements is the back spacer; by means of this device, in case the wrong

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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letter has been punched onto the tape, the tape can be backed up until the incorrect letter is again in the punch. Then the letter may be cancelled by the "Rub out" key. Thus, the purpose of the back spacer on the perforator is exactly the same as its purpose on a typewriter.

The movement is illustrated in Fig. 14(a), which is a veiw of the under side of the base. The stud which carries the feed roller extends through the base, and terminates in a star wheel. A lever and pawl, as indicated in the figure, are mounted so that the pawl engages the star wheel. Hence, when the lever is pushed to the right, the star wheel is turned through a small angle. The star wheel assumes a definite position under the action of the jockey roller which rests upon it. The movement of the star wheel

THE MORAVIA SYSTEM OF TEACHING TYPEWRITING

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is transmitted to the feed roller by means of a pinion which engages a gear on the feed roller. The feed roller is thus rotated through a definite angle, and the paper is moved up a definite amount. The amount of movement is regulated by the adjustment of the jockey roller. The paper may be moved up by the "Rub out" key. Thus, the purpose of the back spacer on the perforator is exactly the same as its purpose on a typewriter.

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The movement is illustrated in Fig. 14(a), which is a view of the under side of the base. The stud which carries the feed roller extends through the base, and terminates in a star wheel. A lever and pawl, as indicated in the figure, are mounted so that the pawl engages the star wheel. Hence, when the lever is pushed to the right, the star wheel is turned through a small angle. The star wheel assumes a definite position under the action of the jockey roller which rests upon it. The movement of the star wheel

turns the feed roller and tape back one step. The lever and pawl are returned to their original positions by a spring. The lever projects from the base at the lower left-hand corner.

THE END-OF-THE-LINE INDICATOR. The next of the new features is the end-of-the-line indicator. This device gives warning when approximately sixty-five characters have been punched onto the tape; sixty-five characters are assumed to constitute a printed line. When the signal is given, the carriage return key is depressed, so that at this point in the message, the printer will begin a new line. The device is therefore seen to perform the same function as a warning bell on a typewriter. Before a message is started, the carriage return key is depressed; this action assures the perfora-

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tor and the printer being in phase as regards the lines.

The indicator is located in the base of the machine; the details of its construction are presented in Fig. 14(a). In this figure, the parts are in the beginning-of-a-line position. As shown, on the feed roller shaft is a small pinion, which drives a 65-tooth gear through the medium of an auxiliary or idler pinion. At each stroke of the hammer, the large gear is turned through the angle of one tooth, so that at the end of a line of sixty-five characters or signals, the large gear will have turned through one complete revolution. The gear turns against the action of a spring, U; this is a flat spiral spring, similar to a small clock spring.

The large gear carries a small cam or disk, D, concentric with it. A lever, L,

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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The indicator is located in the base of the machine; the details of the construction are presented in Fig. 14(a). In this figure, the parts are in the beginning-of-a-line position. As shown, on the feed roller shaft is a small pinion, which drives a 48-tooth gear through the medium of an auxiliary or idler pinion. At each stroke of the hammer, the large gear is turned through the angle of one tooth, so that at the end of a line of sixty-five characters or signals, the large gear will have turned through one complete revolution. The gear turns against the action of a spring, U; this is a flat spiral spring, similar to a small clock spring.

The large gear carries a small cam or disk, D, concentric with it. A lever, L,

is held against the edge of the disk by a spring. An interference pin or stud projects from the face of the large gear in such a manner, that, as the end of the printed line is approached, the stud travels under the lever, lifts it off the disk, and raises it still farther till the contact spring of the lever strikes the fixed point of the contact. This condition is shown in Fig. 14(b). The contact is in series with an indicator lamp and source of current supply, so that when the contact closes, the lamp lights. The lighting of the lamp serves as a warning to the operator that the end of a line is near. The contact is so adjusted that the warning occurs at about the fifty-eighth character of the line.

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Special construction of the large gear is shown in the figure, viz., the

last four teeth of the gear are cut out; the last four teeth are mentioned with the understanding that the teeth are numbered from the one in contact with the idler when all parts are in the initial or beginning-of-a-line position. The reason for this construction of the gear is as follows; if all the teeth were in the gear, there would be no means of stopping rotation at the sixty-fifth character, and the operator might continue punching. The rotation of the gear would continue, so that presently, the interference stud would turn from under the end of the contact lever, thereby releasing that lever and destroying the warning signal. Hence, the last four teeth of the gear are cut out, so that when these spaces reach the idler, any further punching of characters has no effect on the large gear; hence, the warning signal is

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maintained.

The release of the warning signal is effected simaltaneously with the punching of the carriage return signal. The carriage return key operates the selector punching mechanism in the same manner as any other key, but in addition, the key strikes the end of a small bell crank, B, of Fig. 14 (a), at the right end of the base. Through the agency of this bell crank, the key pushes a rod, called the release rod, through a small distance toward the left. The release rod is connected at the left to an arm, H, which carries the idler pinion. This arm is centered on the stud that carries the large gear, and is kept in such a position by a spring, T, that the idler pinion is normally in mesh with the driving pinion and the large gear. But when the release rod is push-

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large gear. But when the release rod is push-

ed to the left, it carries the idler lever and pinion with it. The idler is thereby thrown out of mesh with the feed roller pinion. This condition is illustrated in Fig. 14(c). The large is now free, and runs backward, under the action of the spring, U, until it reaches its original position; i.e., it turns back approximately one revolution.

This movement of the large gear turns the interfernce pin out from under the contact lever and allows that lever to drop back onto the cam; the lamp contact is broken, and the warning therefore ceases. The backward movement of the large gear is stopped by the interference pin striking the end of the contact lever. Such a condition of the parts is shown in Fig. 14(a).

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THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

Part III- The Distribution System.

GENERAL. The distribution system of the Morkrum System of Printing Telegraphy is the same as that of the last introductory system, viz., that of Fig. 6. There are a number of auxiliary devices added to assist in operation, but the general plan and theory are identical with the plan and theory of Fig. 6. For communication in both directions, the apparatus of Fig. 6 must be in duplicate at the two stations; that is, each station must have both transmitting and receiving equipment. It has been found advantageous, therefore, to mount the transmitting and receiving disks of one station, together with their auxiliary equipment, on one base; the complete set of apparatus is called the distributor. By this means, compact construction is obtained, and both receiving and transmitting brush arms may be driven by a single

electric motor.

In the following description of the distributor, the general action of the apparatus will be explained with the aid of rough sketches; the accompanying photographs of the actual machine show the details of construction. The general order of treatment will follow the path of a current pulse through the machine.

The general layout of the distributor is presented in Fig. 15, which is a top or plan veiw of the apparatus. The figure shows the positions of the various parts, but is schematic as far as their construction is concerned.

THE MOTOR. The motor, which drives both brush arms and the tape feed mechanism, is a 1/10 H.P., 1800 R.P.M., 110 volt, D.C., series machine, manufactured by the Gen-

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

electric motor.

In the following description of the distributor, the general section of the apparatus will be explained with the aid of rough sketches; the accompanying photographs of the actual machine show the details of construction. The general order of treatment will follow the path of a current pulse through the machine.

The general layout of the distributor is presented in Fig. 1E, which is a top or plan view of the apparatus. The figure shows the positions of the various parts, but is schematic as far as their construction is concerned.

THE MOTOR. The motor, which drives both brush arms and the tape feed mechanism, is a 1/10 H.P., 1800 R.P.M., 110 volt, U.S. series wound, manufactured by the Ken-

eral Electric Company.

The speed regulating device, shown at the left of the motor, is applied, since it is essential that the machine run at constant speed. As is indicated, the device is merely a fly-ball governor, driven by the motor, and arranged to open a contact when the speed becomes excessive. The contact is placed between the motor and the source of current supply; across the contact is shunted a 1000-ohm resistance. If the motor speeds up, the governor opens the contact, and thereby places the 1000-ohm resistance between the motor and line. The motor therefore slows down until the contact closes again, and shunts the resistance. By means of this governor, large changes may be made in the load or applied voltage without any great effect on the spped of the motor.

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In Fig. 16 is given a detailed

veiw of the governor. The mechanism is supported in a steel "O" frame. This frame is attached to the motor by bolts, as shown. The operation of the governor is apparent from Fig. 16.

THE TAPE CONTACTS. The tape contact mechanism is located at the lower right-hand corner of the machine. This mechanism performs the same function as it did in the introductory system of Fig. 6; that is, it controls the relay pole changers,being itself controlled by the paper tape.

The tape contact pins are five in number, and are held in a vertical plane, as shown in Fig. 17. Each pin is held in a pin-holder, which is a small,round, brass disk. The pin runs through the disk edgeways, and is fuxed to the disk by a set screw. A bearing hole is bored through the disk from

THE MORSE SYSTEM OF PRINTING TELEGRAPHY

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face to face, but considerably off center. All five of the pin holders are mounted on a vertical stud rising from the base. The tape-ends of the pins rest against a metal plate called the tape shield. The opposite ends of the pins are fitted with contact points, which are alligned with contact screws. The screws are supported by an insulating bracket, which, in turn, is supported from the base. This bracket insulates the pins from the base and from each other, For ease and compactness of construction, the contact pins are alternately long and short; the contact screws are correspondingly staggered. By this construction, more room for lock nuts on the screws is provided than would be if the screws were all mounted in a single vertical row. The contacts between the pins and screws are normally held closed by the springs,

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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In the operation of the tape-contact mechanism, the tape runs between the ends of the pins and the tape shield, so that the pins are lifted away from the shield a small amount. This displacement of the pins, though very small, is multiplied by the lever action of the pins and pin-holders to such an extent that it is sufficient to open the contacts. When the perforations in the tape occur. the ends of the pins, under the action of the springs, S, drop through the holes and close their respective contacts.

THE TAPE FEED. The tape-feed mechanism is also apparent from Fig. 17. The feed-wheel consists of a brass disk, fitted with short, steel, wire teeth; the disk is fixed to the lower end of a vertical shaft called the feed shaft. The wheel and shaft

THE MOVEMENT SYSTEM OF PERFORATING INSTRUMENTS

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THE TAPE FEED. The tape-feed mechanism is also apparent from Fig. 17. The feed-wheel consists of a brass disk, fitted with short, steel, wire teeth; the disk is fixed to the lower end of a vertical shaft called the feed shaft. The wheel and shaft

are located on the opposite side of the tape shield from the contact pins and tape, but the edge of the wheel projects a slight distance through a slot in the shield, and is thereby enabled to engage the holes of the tape.

The upper end of the vertical shaft carries a worm wheel which engages a worm on a horizontal transmission shaft from the motor. The worm drive, as shown, is enclosed in a gear-box. The gear-box casting extends downward to form a casing or collar bearing for the vertical feed shaft; it extends to either side to form a sleeve about the transmission shaft. By this arrangement, the vertical shaft and feed-wheel are suspended from the transmission shaft. The lower end of the vertical shaft is normally held against a stop at the bottom of the tape shield

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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by a spring, so that the feed-wheel projects through the slot in the tape shield.

An attachment which aids in the threading of the tape under the tape contact pins is also shown in Fig. 17. This device serves to pull all the contact pins away from the shield, and at the same time, withdraw the feed-wheel from its slot. When the parts are in this position, the tape may easily be threaded under the pins. Upon their release, the contact pins again rest on the tape, and the feed-wheel engages the feed holes.

The attachment is operated by the movement of the lever, L, of Fig. 17. The movement of this lever, through the cam, C, pushes the lower end of the feed-shaft and the feed-wheel away from the shield.

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THE MOREHOUSE SYSTEM OF PRINTING TELEGRAPHY

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The movement of the lever, L,

also raises the contact pins away from the tape shield, through the agency of another lever. By referring to Fig. 17, we see that between tape pins #3 and #4, there is a free space, due to the fact that the row of feed holes occurs in this space. A bell crank is mounted with the pin-holders between holders #3 and #4, the bearing being at the elbow of the crank. One end of the crank extends along the pins a short distance, and terminates in a vertical cross-rod. The cross-rod extends completely across the row of pins. The other end of the crank is connected to the lever, L.

Thus, when the lever, L, is moved to the right, it not only withdraws the feed-wheel from the tape shield, but also lifts all the pins away from the shield. With the parts in these positions, the tape may

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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Thus, when the lever, L, is moved to the right, it not only withdraws the feed-wheel from the tape shield, but also lifts all the pins away from the shield. With the parts in these positions, the tape may

be easily threaded under the pins. When the hand lever, L, is moved back to its normal position, the pins and feed-wheel also return to their original positions; they perform this movement under the action of their return springs.

The tape contact and feeding mechanism just described is mounted on a brass plate, fastened to the main base; hence, the entire mechanism may be easily replaced in case repairs are to be made upon it.

To facilitate such replacements, the worm shaft of the tape-feed is connected to the main shaft from the motor through the coupling, D, of Fig. 17. This coupling consists of two steel disks, one on each shaft. The two disks are faced together and connected, near their edges, by a single pin. Such a coupling furnishes no impedance to the removal

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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To facilitate such replacements, the worm shaft of the tape-feed is connected to the main shaft from the motor through the coupling, D, of fig. IV. This coupling consists of two steel disks, one on each shaft. The two disks are faced together and connected, near their edges, by a single pin. Such a coupling furnishes no impediment to the removal

of the mechanism.

THE TRANSMISSION SHAFT. The transmission for the tape-feed mechanism is shown in Fig. 18. As indicated, the transmission shaft is supported in four bearings, B; one is on a bracket near the motor, the second by the coupling, and the last two on either side of the worm drive of the feed-wheel. These latter two bearings are a part of the bracket which supports the tape shield. The general plan of transmission is this: the motor, through a gear train, drives the gear, G; this gear, through a clutch, drives the transmission shaft, which, in turn, drives the feed-wheel. None of the transmission parts need further comment with the exception of the clutch. The clutch forms a part of an automatic stop system which will now be discussed.

THE MECHANICAL SYSTEM OF MOVING TELEGRAPHY

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THE TRANSMISSION SHAFT. The transmission for the tape-feed mechanism is shown in Fig. 10. As indicated, the transmission shaft is supported in four bearings, B; one is on a bracket near the motor, the second by the coupling, and the last two on either side of the worm drive of the feed-wheel. These latter two bearings are a part of the bracket which supports the tape shield. The general plan of transmission is this: the motor, through a gear train, drives the gear, G; this gear, through a clutch, drives the transmission shaft, which, in turn, drives the feed-wheel. None of the transmission parts need further comment with the exception of the clutch. The clutch forms a part of an automatic stop system which will now be discussed.

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

THE AUTOMATIC STOP. It has been found necessary to apply an automatic stop or control device to the tape-feed mechanism. When this device is omitted, difficulties arise when the perforator operator does not work fast enough to supply the distributor with tape. The tape tears between the two machines, or else the distributor feed tears the feed holes out of the tape. It is with the idea of overcoming this difficulty that the manufacturer adds the automatic stop.

The general plan of the device is this: before entering the tape feed of the distributor, the tape loops over a small lever. This lever carries a contact point at its opposite end; a second point is fixed to the base. The opening and closing of the contact controls a magnet called the

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cut-out magnet, which, in turn, controls the feed clutch in the transmission shaft. Ordinarily, the tape between the perforator and distributor hangs loosely and exerts no pull on the lever; but if the tape tightens up, as it will when the perforator is working slower than the distributor, it pulls on the lever and opens the contact. The solenoid is de-energized and opens the clutch. The tape feed is thereby stopped before the tape is torn. When the tape again becomes loose, the lever is released, the contact closes, the clutch solenoid is energized, and the clutch re-engages, so that the tape feed proceeds as before.

The automatic stop as actually applied to the machine is shown in Fig. 18(a) and (b). The gear, G, is made in one piece

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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The detailed construction of the clutch is shown in Fig. 18(a) and (b). On the transmission shaft is mounted the carrier, B, which carries the clutch dog, D. A spring, S, holds the dog against the edge of the disk, A. In the edge of A is a small notch, N, and at the end of the dog is a tooth which engages the notch. It will be seen, therefore, that as long as the dog, D, bears against the edge of the disk, A, the

THE MORTON SYSTEM OF PRIMARY TRANSMISSION

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The detailed construction of the clutch is shown in Fig. 18(a) and (b). On the transmission shaft is mounted the carrier, R, which carries the clutch dog, D. A spring, S, holds the dog against the edge of the disk, A. In the edge of A is a small notch, N, and at the end of the dog is a tooth which engages the notch. It will be seen, therefore, that as long as the dog, D, bears against the edge of the disk, A, the

clutch is engaged. The clutch is disengaged when the dog, D, is held away from the disk, A.

The tripping mechanism for disengaging the clutch is also shown in Figs. 18. On the base, and near the clutch, is located the clutch solenoid, M. The solenoid has an armature, pivoted at the lower end, which carries a stop pin, P. Ordinarily, the solenoid is energized, and therefore holds its armature away from the clutch. However, when the control contact is opened by the tightening of the tape, the solenoid is de-energized, and its armature is drawn away by a spring. This armature movement thrusts the stop pin, P, into the path of the dog, D, so that the dog strikes the pin. The dog is tripped out of the notch, and the clutch is disengaged.

THE MORRUM SYSTEM OF TRIPPING TYPEWRITER

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The tripping mechanism for disengaging the clutch is also shown in Fig. 18. On the base, and near the clutch, is located the clutch solenoid, M. The solenoid has an armature, pivoted at the lower end, which carries a stop pin, P. Ordinarily, the solenoid is energized, and therefore holds its armature away from the clutch. However, when the control contact is opened by the tightening of the tape, the solenoid is de-energized, and its armature is drawn away by a spring. This armature movement thrusts the stop pin, P, into the path of the dog, D, so that the dog strikes the pin. The dog is tripped out of the notch, and the clutch is disengaged.

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

Means are provided for the holding of the dog, D, away from the disk, A. On the transmitting shaft, and beside the carrier, B, is mounted a disk, C. This disk contains a wide shallow V-notch in its edge. A lever, T, is pivoted at one end to the base plate of the machine; the upper end bears against the cam, C, under the action of a spring. The end of the lever is so shaped as to fit in the notch of the disk, C.

In the operation of the device, the shaft and the disk, C, ordinarily revolve so fast that the lever has not time to drop into the notch of the disk; also, the notch is so shallow that should the lever drop into it, the lever could not hold the disk against the driving force of the shaft, but would be raised out of the notch as the disk turned. When the stop pin, P, trips out the dog, D,

THE MONTRUM SYSTEM OF PRINTING TELEGRAPHY

Means are provided for the holding of the dog, D, away from the disk. A. On the transmitting shaft, and beside the carrier, B, is mounted a disk, C. This disk contains a wide shallow V-notch in its edge. A lever, T, is pivoted at one end to the base plate of the machine; the upper and bevel against the cam, C, under the action of a spring. The end of the lever is so shaped as to fit in the notch of the disk, C.

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the momentum of the carrier causes the parts to assume to position of Fig. 18(b). The dog, D, is now well clear of the disk, but the spring on D tends to rotate the carrier backward until the dog drags on the disk, A. However, the notch on the disk, C, is cut so that just as the parts come to rest in the position of Fig. 18(b), the notch in C stops under the end of the lever, T. The end of the lever drops into the notch and locks the parts in position. Hence, the dog, D, is kept clear of the disk, A.

When the dog, D, is released by the stop pin, P, it drops onto the revolving disk, A. As the notch in A passes under the dog, the dog drops into the notch, and the clutch is thereby re-engaged. The notch in the cam, C, is shallow, so that the lever easily rises out of the notch and rides on

THE MOMENTUM SYSTEM OF PRINTING TELEGRAPHY

the momentum of the carrier causes the parts to assume to position of Fig. 18(b). The dog, D, is now well clear of the disk, but the spring on D tends to rotate the carrier backward until the dog drags on the disk, A. However, the notch on the disk, C, is cut so that just as the parts come to rest in the position of Fig. 18(b), the notch in C stops under the end of the lever, E. The end of the lever drops into the notch and locks the parts in position. Hence, the dog, D, is kept clear of the disk, A.

When the dog, D, is released by the stop pin, F, it drops onto the revolving disk, A. As the notch in A passes under the dog, the dog drops into the notch, and the clutch is thereby re-engaged. The notch in the cam, C, is shallow, so that the lever easily rises out of the notch and rides on

the edge of the disk, thereby leaving the entire clutch free to rotate.

THE CUT-OUT. A so-called cut-out mechanism is also shown in Figs. 18. The purpose of the device is to operate a relay, which operation causes both front and back contacts of the pole changer relays (identical with the pole changer relays of Fig. 6) to be connected to the positive side of the battery. Hence, when the device operates, only positive line impulses are sent out; this condition is the same as when the "rub out" signal is given, which signal consists of all positive intervals, and it will be remembered that the printer does not respond to such signals. When the tape feed stops for any cause, the cut-out device operates, so that the printer is kept inoperative. If it were not for this device, the printer would print

THE MORSEUM SYSTEM OF PRINTING TELEGRAPHY

the edge of the disk, thereby leaving the entire circuit free to rotate.

THE CUT-OUT. A so-called cut-out mechanism is also shown in Fig. 18. The purpose of the device is to operate a relay, which operation causes both front and back contacts of the pole changer relays (identical with the pole changer relays of Fig. 6) to be connected to the positive side of the battery. Hence, when the device operates, only positive line impulses are sent out; this condition is the same as when the "run out" signal is given, which signal consists of all positive intervals, and it will be remembered that the printer does not respond to such signals. When the tape feed stops for any cause, the cut-out device operates, so that the printer is kept inoperative. If it were not for this device, the printer would print

over and over again whatever character happened to be in the tape contact mechanism when the tape feed stopped.

The details of this device are also shown in Figs. 18. On the feed shaft is mounted a disk, K, containing a wide notch, as shown; against the disk bears the lever, H, pivoted at its lower end, and held against the disk by a spring as shown. The lever, H, carries the movable point of the contact, J. When the lever bears against the edge of the disk, the contact is held open, but if the lever drops into the notch, the contact is closed. The details of the cut-out relay and of the electrical connections will be given later. The cam, K, is so placed on the feed shaft that when the shaft stops and is held by the disk Ç and its lever, the notch in K will lie under the end of

THE MORSE SYSTEM OF PRINTING TELEGRAPHY

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pened to be in the tape contact mechanism
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The details of this device
are also shown in Figs. 18. On the feed
shaft is mounted a disk, K, containing a
wide notch, as shown; against the disk bears
the lever, N, pivoted at the lower end, and
held against the disk by a spring as shown.
The lever, N, carries the movable point of
the contact, J. When the lever bears against
the edge of the disk, the contact is held o-
pen, but if the lever drops into the notch,
the contact is closed. The details of the
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tions will be given later. The cam, K, is so
placed on the feed shaft that when the shaft
shown and is held by the disk Q and its lev-
er, the notch in K will lie under the end of

the lever, H; hence, during this time of stop, the printer will remain inoperative. When the feed shaft is revolving at its usual speed, the lever, H, does not have time to drop into the notch.

THE TRANSMITTING DISK. Next in the order of treatment comes the transmitting disk and brush arm. The disk is located behind the tape-feed mechanism, as is indicated in the general plan of Fig. 15.

The driving of the brush arm by the motor is accomplished through the gear train and main shaft, as shown in Fig. 15, the main shaft carrying the brush arm. The main shaft is supported at its ends in bearings, B, one being on a bracket near the motor, and the other being on the bracket which supports the transmitting disk. The shaft passes through a large hole in the middle of

THE MOVEMENT OF PRINTING TELEGRAPHY

the lever, H; hence, during this time of stop, the printer will remain inoperative. Then the feed shaft is revolving at its usual speed, the lever, H, does not have time to drop into the notch.

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the disk to the bearing at the back side of the disk. The bearing support is shown in Fig. 19.

The transmitting disk is of fiber, about two and one-half inches in diameter, and is supported from the base by a bracket (see Fig. 19). The disk carries eight brass contact buttons, set flush with the face of the disk. Connection is made to the buttons through leads at the back.

The functions of the eight buttons are indicated in Fig. 15. There are the five code buttons, 1, 2, 3, 4, and 5, a lamp button, L, and the two synchronizing buttons, the first positive and the second negative. The functions of the code buttons have already been explained. The lamp button is used in the operation of a signal lamp, by which the receiving station signals the

THE MORRUM SYSTEM OF PRINTING TELEGRAPHY

the disk to the bearing at the back side of the disk. The bearing support is shown in Fig. 19.

The transmitting disk is of fiber, about two and one-half inches in diameter, and is supported from the base by a bracket (see Fig. 19). The disk carries eight brass contact buttons, set flush with the face of the disk. Connection is made to the buttons through leads at the back.

The functions of the eight buttons are indicated in Fig. 18. There are the five code buttons, 1, 2, 3, 4, and 5, a jump button, J, and the two synchronizing buttons, the first positive and the second negative. The functions of the code buttons have already been explained. The jump button is used in the operation of a signal jamy, by which the receiving station signals the

transmitting station or vice versa. The synchronizing buttons are used in keeping the transmitting brush arm at one station and the receiving brush arm at the other station in step; the synchronizing system will be explained a little later. It suffices to say here that the positive button is connected permanently to the positive side of the battery, whereas the negative button is connected permanently to the negative side of the battery.

The brush arm and brush are mounted on the main shaft on an insulating bushing. The brush arm is of brass, whereas the brush is a copper strip, bent into a "U"; one end is attached to the brush, the other trailing over the disk. The brush arm also carries a felt wiper, as shown in Fig. 19, which wipes over the disk and keeps it

THE MOTOREX SYSTEM OF PRINTING TELEGRAPHY

transmitting station or vice versa. The synchronizing buttons are used in keeping the transmitting brush arm at one station and the receiving brush arm at the other station in step; the synchronizing system will be explained a little later. It suffices to say here that the positive button is connected permanently to the positive side of the battery, whereas the negative button is connected permanently to the negative side of the battery.

The brush arm and brush are mounted on the main shaft on an insulating bushing. The brush arm is of brass, whereas the brush is a copper strip, bent into a "U"; one end is attached to the brush, the other resting over the disk. The brush arm also carries a felt wiper, as shown in Fig. 12, which wipes over the disk and keeps it

free from dirt.

Contact is made with the brush arm by a wire brush, consisting of a number of vertical wires. This second brush bears against the hub of the brush arm. The support of the brush in its bracket is clearly shown in Fig. 19.

THE POLE CHANGER RELAYS. Considering the path of a current impulse through the apparatus as our general order of treatment of the subject, we find that the pole changer relays come next in order. The five pole changer relays, whose function is the same as in Fig. 6, are located in a row at the upper left hand corner of the distributor base (see Fig. 15). In addition to the five instruments mentioned, there is an additional one, the cut-out relay, whose function is to connect both front and back contacts of

THE CONTROL PANEL OF PENNING TELEGRAPHY

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THE POLE CHANGER RELAYS. Controlling the apparatus as our general order of transfer of the subject, we find that the pole changer relays come next in order. The five pole changer relays, whose function is the same as in Fig. 6, are located in a row at the upper left hand corner of the distributor base (see Fig. 15). In addition to the five instruments mentioned, there is an additional one, the cut-out relay, whose function is to connect both front and back contacts of

the others to the positive side of the battery. The sixth pole changer relay is similar in construction to the others.

A detailed view of one of the pole changer relays is presented in Fig. 20. The solenoid, as mounted on the distributor is vertical; it is fitted with strap iron pole pieces, P_1 and P_2. The bottom pole piece, P_2, is prolonged and bent up along the front of the coil; the pole piece extends about half way up the coil. The armature is of the same stock as the pole pieces, and is hinged to the armature as shown. The armature carries the contact lever, C, which is insulated from the armature by a sheet of fiber. A bracket is attached to the lower part of P_2, runs up in front of the armature, and carries the fixed relay contacts. The armature is normally kept against the back

THE MORRISON SYSTEM OF INSULATED INTERCONNECTION

armature is normally kept against the back and carries the fixed relay contacts. The part of L_5, runs up in front of the armature, fiber. A bracket is attached to the lower insulated from the armature by a sheet of ture carries the contact lever, C, which is hinged to the armature as shown. The armature of the same stock as the pole piece, and is about half way up the coil. The armature is the front of the coil; the pole piece extends piece, P_5, is prolonged and bent up along ron pole pieces, P_1 and P_3. The bottom pole ator is vertical; it is fitted with strap hinge, 20. The solenoid, as mounted on the distribthe coupling relays is represented in Fig. 1.

A detailed view of one of

ler in construction to the others.

tery. The sixth pole changer relay in unit- the others to the positive side of the bat-

contact by the flat steel spring, S.

When the solenoid is energized, the upper part of the armature is drawn toward the upper pole piece, P_1, which movement closes the front relay contact. When the solenoid is de-energized, the armature, under the action of the spring, S, returns to its original position.

In Fig. 20(a) is shown the conventional symbol used for such a relay in wiring diagrams.

Next in order of discussion occurs the main-line pole changer; however, we will omit this discussion for a time, and next consider the receiving apparatus.

THE RECEIVER DISK. The receiver disk and brush arm are located behind the transmitter disk, as is illustrated in Fig. 15. The construction and mounting of the disk is, in

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

contact by the flat steel spring, S.

When the solenoid is ener-
gized, the upper part of the armature is
drawn toward the upper pole piece, P', which
movement closes the front relay contact.
When the solenoid is de-energized, the arma-
ture, under the action of the spring, S, re-
turns to its original position.

In Fig. 20(a) is shown the
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THE RECEIVER DISK. The receiver
disk and brush arm are located behind the trans-
mitter disk, as is illustrated in Fig. 12. The

general, the same as that of the transmitter disk. One difference in the two is that the receiver disk possesses one large button at A, (see Fig. 15) instead of the two synchronizing buttons which the other possesses. The other difference is in the attachment of the disk to the bracket. The receiver disk is attached to the bracket by thumb-screws in such a manner that after loosening the thumb-screws, one may turn the entire disk through a small angle. The theory of such an adjustment was presented on page 30 ff. The disk has a scale marked on its edge, so that its angular movement can be gauged.

THE TRANSMISSION SHAFT. The driving of the receiving brush arm from the motor is accomplished through a main shaft, carrying the brush arm, and a gear train, as

NEW MORSEIAN SYSTEM OF TRAINING TELEGRAPHERS

general, the same as that of the transmitter disk. One difference in the two is that the receiver disk possesses one large button at A, (see Fig. 15) instead of the two synchronizing buttons which the other possess. The other difference is in the attachment of the disk to the bracket. The receiver disk is attached to the bracket by thumbscrews in such a manner that after loosening the thumb-screws, one may turn the entire disk through a small angle. The theory of such an adjustment was presented on page 30 ff. The disk has a scale marked on its edge, so that its angular movement can be gauged.

THE TRANSMISSION SHAFT. The driving of the receiving brush arm from the motor is accomplished through a main shaft, carrying the brush arm, and a worm train, as

was the case of the transmitter. The shaft is supported on two bearings, one on a bracket near the motor and the other near the disk and on the disk bracket. The drive, however, from the motor to the brush arm is not direct, but is through a so-called synchronizing clutch. This clutch constitutes a part of the equipment for keeping the receiver brush at one end of the line in synchronism with the transmitter brush at the opposite end of the line. We will now consider the synchronizer, of which the clutch forms a part.

THE SYNCHRONIZER. The scheme of the synchronizing apparatus is as follows: The driving motors at the two ends of the line run at approximately the same speeds, but the receiver brush arm is geared to run a little faster than the transmitter arm. The function of the synchronizer is to retard the

THE MORELAND SYSTEM OF PRINTING TELEGRAPHY

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THE SYNCHRONIZER. The scheme of the synchronizing apparatus is as follows: The driving motors at the two ends of the line run at approximately the same speeds, but the receiver brush arm is geared to run a little faster than the transmitter arm. The function of the synchronizer is to retard the

receiver brush at suitable intervals, so as to keep the receiver arm sensibly in step with the other. The occurrence of the correction interval is governed by the relative positions of the two arms, so that whenever the receiver brush has attained a definite small angle of advance over the transmitter brush, a correction interval takes place, so that the receiver brush is drawn back into its proper position. This retardation of the receiver brush is accomplished by the synchronizing mechanism, which is controlled by the two synchronizing pulses, the first negative and the second positive, which the transmitter brush sends out between sussessive letters. The two synchronizing buttons were mentioned in the description of the transmitter disk.

transmitter disk.

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tive letters. The two synchronizing buttons
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by the two synchronizing pulses, the first
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THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

A schematic view of the synchronizing mechanism is presented in Fig. 21. This figure illustrates only the general principal underlying the system: certain modifications are necessary before it can be used in actual operation. The cam marked correcting cam in Fig. 21 is mounted on the receiver brush arm shaft. A contact arm bears against the cam, under spring tension, so that every revolution of the cam, the end of the lever drops into a notch in the cam face. This movement of the lever close the contact, which is in a circuit composed of the contact itself, the corrector magnet, the marking contact of the main line relay, local battery, and ground.

Suppose the transmitter sends out the negative synchronizing pulse; the main line relay closes the marking contact.

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Such a condition is indicated in Fig. 21. Now the notch in the face of the correcting cam is so placed with reference to the receiver brush arm that if the receiver arm is ahead of the transmitter arm, the synchronizing pulse will occur while the cam slot is under the end of the contact lever. At this time, therefore, the cam contact is closed, and the main line relay is on its marking contact; hence the corrector magnet is energized, and applies a correction. The next pulse is positive, so that the corrector magnet is immeidately de-energized by the opening of the relay contact. If the correction need be but slight, the corrector magnet may be de-energized through the opening of the cam contact.

When the receiver brush is in step with the other, the cam contact does not

THE MORSEGRAM SYSTEM OF PRINTING TELEGRAPHY

such a condition is indicated in Fig. 21. Now the motor in the face of the corresponding cam is so placed with reference to the receiver brush arm that if the receiver arm is ahead of the transmitter arm, the synchronizing pulse will occur while the cam slot is under the end of the contact lever. At this time, therefore, the cam contact is closed, and the main line relay is on its marking contact; hence the corrector magnet is energized, and applies a correction. The next pulse is positive, so that the corrector magnet is immediately de-energized by the opening of the relay contact. If the correction need be but slight, the corrector magnet may be de-energized through the opening of the cam contact.

When the receiver brush is in step with the other, the cam contact does not

close until after the synchronizing pulse has occurred, so that no correction is applied.

As was previously stated, the scheme of Fig. 21 is not the one used in practical operation, since it is necessary to modify the control of the corrector magnet somewhat. However, before taking up these modifications, we will consider the synchronizing clutch, by which the corrector magnet is enabled to retard the receiver brush arm.

The synchronizing clutch is shown in Fig. 22. The motor drives the receiver shaft through a worm on the the motor shaft and a worm on the receiver shaft. The worm-wheel, and a gear, A, of Fig. 22, are in one piece together with the connecting sleeve. The sleeve is bored to make a bearing fit with the shaft, but is not fixed to the

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

close until after the synchronizing pulse has occurred, so that no correction is applied.

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shaft. To the brush arm shaft is attched the carrier, B, which carries the pinion, P, meshing with the gear, A, and the pinion, Q, meshing with the pinion, P. A star-wheel is mounted with the pinion, Q, and a jockey roller bears against it, under the action of a spring, S. By this arrangement, as long as the jockey roller holds the star-wheel locked in position, the carrier, B, the shaft, and the driving gears, A, and C, all revolve together. If however, the star-wheel is turned, the two pinions, Q and P, are turned, and the carrier, B, rotates with respect to the gear, A, and hence with respect to the driving motor. Whether the brush arm is advanced or retarded, with respect to the moter, depends upon the direction is which the star-wheel is turned.

Below the clutch is the cor-

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

shaft. To the brush arm shaft is attached the carrier, B, which carries the pinion, F, meshing with the gear, A, and the pinion, G, meshing with the pinion, F. A star-wheel is mounted with the pinion, G, and a jockey roller bears against it, under the action of a spring, S. By this arrangement, as long as the jockey roller holds the star-wheel locked in position, the carrier, B, the shaft, and the driving gears, A, and G, all revolve together. If however, the star-wheel is turned, the two pinions, G and F, are turned, and the carrier, B, rotates with respect to the gear, A, and hence with respect to the driving motor. Whether the brush arm is advanced or retarded, with respect to the motor, depends upon the direction in which the star-wheel is turned.

Below the pinion is the cor-

recting magnet, to whose armature is attached a small interference pin, P. The magnet is so located that when it becomes energized, it draws the interference pin into the path of the star-wheel. Therefore, if the magnet be energized while the star-wheel is revolving about the central shaft, the pin trips the star-wheel through the angle of one tooth.

The result of the movement of the interference pin is the retardation of the brush arm. As was just shown, the clutch locks the receiver shaft and the driving gears, A and C, together, so that the shaft, clutch, and gears revolve in unison. If however, while they are revolving, the interfernce pin trips the star-wheel, the carrier, B, the star-wheel, and the shaft are stepped back slightly. Thus, when the receiver brush gets too far ahead of the transmitter brush at the

THE MODERN CREATION OF RELIEVING MECHANISM

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opposite station, a synchronizing pulse occurs, which causes the corrector magnet to pick-up, and thereby apply a correction to the brush arm.

The retardation of the receiver arm is very slight, but the driving motors run at such nearly constant speeds, that the arms turn through several revolutions before correction become necessary.

As was previously stated, the control of the corrector magnet is somewhat different from that shown in Fig. 21. The corrector magnet does not have time to pick-up under the action of the synchronizing pulse. It is necessary, therefore, to prolong the influence of the pulse. Two relays are added to the scheme, one a quick-acting, and the other a slow-acting instrument. The mechanical construction of the re-

THE MOMENTUM EFFECT OF PICKING TRANSPARENT

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lays is the same as that of the relay pole changers, already described.

The new scheme, as is used in practical operation, is presented in Fig. 23. In this figure, the quick acting relay is marked "X", and the slow-acting is marked "Y". By reference to Fig. 23, we that when the correcting pulse is received, if the cam contact is closed, the current passes from the positive side of the local battery, through the printer relay and cam contacts, through the windings of X and Y in multiple, to the negative side of the battery. Relay X picks-up and closes contact a. The correcting magnet is now connected across the local battery through the contacts a and b. Also, both relay windings are connected in multiple across the local battery. The slow-acting relay, Y, now picks-up and opens contact b; the open-

THE MORSE SYSTEM OF SIGNALING THROUGHOUT

lays is the same as that of the relay pole changers, already described.

The new scheme, as is used in practical operation, is presented in Fig. 23. In this figure, the quick acting relay is marked "X", and the slow-acting is marked "Y". By reference to Fig. 23, we that when the corresponding pulse is received, if the cam contact is closed, the current passes from the positive side of the local battery, through the printer relay and cam contacts, through the windings of X and Y in multiple, to the negative side of the battery. Relay X picks-up and closes contact a. The corresponding magnet is now connected across the local battery through the contacts a and b. Also, both relay windings are connected in multiple across the local battery. The slow-acting relay, Y, now picks-up and opens contact b; the open-

ing of contact b de-energizes both relay windings, so that the contacts a and b are opened. When a and b are open, the correcting magnet is disconnected from the battery; hence, the magnet is de-energized. But in the meantime, it has performed its synchronizing function, i.e., it has, through the agency of the synchronizing clutch, retarded the brush arm.

If, when the synchronizing pulse is received, the cam contact is open, (as it will be when the brush arms are in step) there is no current path through the cam contact to the relays X and Y. Hence, the relays are not energized and no correcting action occurs.

The purpose of the 200-ohm resistance shunted across the corrector magnet is to absorb the inductive kick, present

CHE MINIMUM AMOUNT OF WIRING NECESSARY

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ings, so that the contacts a and b are open-
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ing action occurs.

The purpose of the 200-ohm
resistance mounted across the corrector mag-
net is to absorb the inductive kick, present

when the circuit of the magnet is opened. If this resistance were not provided, destructive arcing would occur at the contact b or at the cam contact.

We will now complete the discussion of the electrical circuits of the distributor.

THE DISTRIBUTOR CIRCUITS. The complete circuits of the distributor are shown in Fig. 24. It is obviously impractical for us to attempt a study of the circuits as presented in this figure; hence, we will separate the constituent circuits from the rest and study them one at a time.

THE MOTOR CIRCUIT. The motor circuit is so simple that it need not be seprated from the other circuits of Fig. 24. As is indicated, the motor, together with the governor contact and the 1000-ohm resistance

THE MONTRUM SYSTEM OF INSTRUCTIONAL TELEVISION

when the circuit of the magnet is opened. If this resistance were not provided, destructive arcing would occur at the contact b or at the cam contact.

We will now complete the discussion of the electrical circuits of the distributor.

THE DISTRIBUTOR CIRCUITS. The complete circuits of the distributor are shown in Fig. 24. It is obviously impracticable for us to attempt a study of the circuits as presented in this figure; hence, we will separate the committment circuits from the test and study them one at a time.

THE MOTOR CIRCUIT. The motor circuit is so simple that it need not be separated from the other circuits of Fig. 24. As is indicated, the motor, together with the governor contact and the 1000-ohm resistance

in multiple, are connected across the 110-volt battery.

TRANSMITTER DISK CIRCUITS.

The circuits of the tape contacts and relay pole changers are shown in Fig. 25. The connections are similar to those of the introductory system shown in Fig. 6, except for the addition of the 900-ohm resistance, D, in series with the back points of the relay pole changers, and for the addition of the cut-out relay. The purpose of the resistance, D, is to prevent the short-circuit of the battery when one or more of the relay pole changer tongues are on their front contacts and the transmitter brush is on the corresponding button. The cut-out relay was discussed before; it is controlled by the tape feed cut-out. As is indicated, when the cut-out relay is de-energized, as is normally the

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

in multiple, are connected across the 110-volt battery.

TRANSMITTER DIRECTION.

The circuits of the tape contacts and relay pole changers are shown in Fig. 28. The connections are similar to those of the introductory system shown in Fig. 6, except for the addition of the 500-ohm resistance, D, in series with the back points of the relay pole changer, and for the addition of the cut-out relay. The purpose of the resistance, D, is to prevent the short-circuit of the battery when one or more of the relay pole changer tongues are on their front contacts and the transmitter break is on the correspondding button. The cut-out relay was discussed before; it is controlled by the tape feed cut-out. As is indicated, when the cut-out relay is de-energized, as is normally the

case, the armature rests against its back point, so that the back points of all the relay pole changers are negative. When the cut-out relay is energized, by the closing of the cut-out cam contact, its armature is drawn over to the front point. When the armature is in this position, both the front and back contacts of the relay pole changers are positive. Hence, by means of the cut-out mechanism, all-positive impulses are transmitted through the line whenever the cut-out is in operation.

Fig. 25 also comprises the circuits of the main line pole changer. The buttons of the transmitting disk are connected to the tongues of the relay pole changers; the brush arm is connected to one terminal of the main line pole changer; the other terminal of the main line pole changer is con-

THE NORTHERN ALASKA OIL PIPELINE UNDERTAKING

minal of the main line pole changer is connected to the main line pole changer; the other terminal of the main line pole changer is connected to the brush arm in the reversing disk; the contacts of the relay pole changers are positive. Hence, by means of the cut-out mechanism, all-positive impulses are transmitted through the line whenever the cut-out is in operation.

Fig. 25 also comprises the circuits of the main line pole changer. The buttons of the transmitting disk are connected to the contacts of the relay pole changers; one terminal of the main line pole changer is connected to the front point. When the armature is in this position, both the front and back contacts of the relay pole changers are positive. Hence, by means of the cut-out mechanism, all-positive impulses are transmitted through the line whenever the cut-out is in operation.

Fig. 25 also comprises the

nected to the local battery through the 900-ohm resistances, A, B, C, and D. A study of the connections of the main line pole changer and resistances will show that two 900-ohm resistances, A and B or C and D, are always in series with the main line pole changer while it is connected across the local battery. Hence, the current through the coils is limited to a value which the winding will safely carry.

The tongue of the main line pole changer is connected to the middle point of the winding of a milammeter; we are not at present concerned with the purpose of the milammeter. At this point of connection, the circuit divides. One path consists of half the winding of the milammeter, one coil of the main line relay, the artificial line, and ground. The other path leads through the

THE MORSE SYSTEM OF PRINTING TELEGRAPHY

The tongue of the main line pole changer is connected to the middle point of the winding of a milammeter; we are not at present concerned with the purpose of the milammeter. At this point of connection, the circuit divides. One path consists of half the winding of the milammeter, one coil of the main line relay, the artificial line, and ground. The other path leads through the

other half of the winding of the milammeter, through the other coil of the main line relay, and thence to the line. We see, therefore, that, as in Fig. 6, the armature of the main line pole changer is connected to the line. One point of the main line pole changer is positive, whereas the other is negative; these two points are respectively connected, as before, to the positive and the negative legs of the main line battery. This battery is not shown in Fig. 25. The operation of this much of the transmitting circuit is exactly the same as that of the scheme shown in Fig. 6.

The transmitting disk of Fig. 25 has the eight contact buttons, previously discussed. The function of the five code buttons is apparent. The synchronizing and lamp buttons, however, may require a word of ex-

THE MORSKOM SYSTEM OF TEACHING TELEGRAPHY

other half of the winding of the milammeter, through the other coil of the main line relay, and thence to the line. We see, therefore, that, as in Fig. 6, the armature of the main line pole changer is connected to the line. One point of the main line pole changer is positive, whereas the other is negative; these two points are respectively connected, as before, to the positive and the negative legs of the main line battery. This battery is not shown in Fig. 28. The operation of this mesh of the transmitting circuit is exactly the same as that of the scheme shown in Fig. 6.

The transmitting disk of Fig. 28 has the eight contact buttons, previously discussed. The function of the five code buttons is apparent. The synchronizing and lamp buttons, however, may require a word of ex-

planation.

The negative synchronizing button is permanently connected to the negative side of the local battery, so that only marking impulses are sent out by this button. It controls the main line pole changer in exactly the same manner as the code buttons do.

The positive synchronizing button is the same as the negative, except that it is connected to the positive side of the local battery. Hence, only spacing pulses are sent out by this button.

The lamp signal button is marked "L" in the figure. This button may be either positive or negative, depending upon the position of the break key. Ordinarily, the break key connects the lamp button to the positive side of the battery, so that only positive or spacing impulses are sent

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The negative synchronizing button is permanently connected to the negative side of the local battery, so that only marking impulses are sent out by this button. It controls the main line pole changer in exactly the same manner as the code buttons do.

The positive synchronizing button is the same as the negative, except that it is connected to the positive side of the local battery. Hence, only spacing impulses are sent out by this button.

The lamp signal button is marked "L" in the figure. This button may be either positive or negative, depending upon the position of the break key. Ordinarily, the break key connects the lamp button to the positive side of the battery, so that only positive or spacing impulses are sent

out by the button. If the break key is depressed, however, it connects the button to the negative side of the battery, and hence marking impulses are transmitted. At the receiving station, these pulses control a lamp relay, similar to the other local receiving relays; this lamp relay, in turn, controls a lamp. Normally, the lamp is not lighted, but if the break key be depressed, the lamp at the other station lights. This lamp is used for the transmission of signals between operators at the two station, and does not interfere with the message.

AUTOMATIC STOP CIRCUITS. The circuit of the automatic stop for the tape-feed mechanism, comprising the stop lever and cut-out magnet, is clear from Fig. 24. The stop lever contact is in series with the cut-out magnet, and the two are connected across the local battery.

THE MONARCH SYSTEM OF SWITCHING TELEGRAPH

out by the button. If the break key is depressed, however, it connects the button to the negative side of the battery, and hence marking impulses are transmitted. At the receiving station, these pulses control a lamp relay, similar to the other local receiving relays; this lamp relay, in turn, controls a lamp. Normally, the lamp is not lighted, but if the break key be depressed, the lamp at the other station lights. This lamp is used for the transmission of signals between operators at the two station, and does not interfere with the message.

AUTOMATIC STOP CIRCUITS. The circuit of the automatic stop for the tape-feed mechanism, comprising the stop lever and cut-out magnet, is clear from Fig. 84. The stop lever contact is in series with the cut-out magnet, and the two are connected across the local battery.

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

THE RECEIVER CIRCUITS. The receiver circuits are shown, somewhat simplified, in Fig. 26. The path of the impulse from line to ground is through one coil of the main line relay, through the milammeter, through the other coil of the main line relay, and through the artificial line to ground at G'. The milammeter is connected in series with the main line relay, so that a more accurate idea of the strength of the incoming line impulses may be obtained than would be furnished by the movement of the main line relay armature. The artificial line is merely an adjustable resistance and capacity in parallel, connected between the main line relay and ground. The function of the artificial line will be taken up during the discussion of the polar duplex.

The tongue of the main line

THE MORKRUM SYSTEM OF KEYING TELEGRAPHY

THE RECEIVER CIRCUITS. The receiver circuits are shown, somewhat simplified, in Fig. 26. The path of the impulse from line to ground is through one coil of the main line relay, through the milammeter, through the other coil of the main line relay, and through the artificial line to ground at B'. The milammeter is connected in series with the main line relay, so that a more accurate idea of the strength of the incoming line impulses may be obtained than would be furnished by the movement of the main line relay armature. The artificial line is merely an adjustable resistance and capacity in parallel, connected between the main line relay and ground. The function of the artificial line will be taken up during the discussion of the polar duplex.

The tongue of the main line

relay is connected to the positive side of the local battery; the two points are connected to the two coils of the printer relay, as was the case in the introductory system. The remaining two terminals of the printer relay coils are strapped together, and this point connected to the negative side of the local battery through a 2000-ohm resistance. By this arrangement, the printer relay follows the movements of the main line relay. The purpose of the 2000-ohm resistance is to limit the current through the printer relay.

One point of the printer relay is dead. The other point is connected to the positive side of the local battery. The armature of the relay is connected to the receiver brush arm. Hence, when spacing signals are sent out from the transmitting station, the tongue of the printer relay goes

THE MORKUM SYSTEM OF PRINTING TELEGRAPHY

relay is connected to the positive side of the local battery; the two points are connected to the two coils of the printer relay, as was the case in the introductory system. The remaining two terminals of the printer relay coils are strapped together, and this point connected to the negative side of the local battery through a 2000-ohm resistance. By this arrangement, the printer relay follows the movements of the main line relay. The purpose of the 2000-ohm resistance is to limit the current through the printer relay.

One point of the printer relay is dead. The other point is connected to the positive side of the local battery. The armature of the relay is connected to the receiver brush arm. Hence, when operating signals are sent out from the transmitting station, the tongue of the printer relay goes

to its dead point, and the receiver brush is not energized. When a marking pulse is received, the tongue of the printer relay goes to the opposite point, which is connected to the positive side of the local battery; hence, the receiver brush arm is energized. The operation, therefore, is exactly the same as the system of Fig. 6.

The circuits of the local receiving relays have been omitted; they will be considered during the discussion of the printer.

The synchronizing circuit, as previously described, was taken from Fig. 24. Hence, no further explanation is required.

As for the buttons on the receiver disk, and the circuits which they control, the buttons are arranged just the same as those of the transmitter disk, except that

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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receiver brush arm is energized. The opera-

ative side of the local battery; hence, the

opposite point, which is connected to the po-

the tongue of the printer relay goes to the

energized. When a marking pulse is received,

to its dead point, and the receiver brush is not

the two synchronizing buttons of the transmitter have been combined into one large button on the receiver disk. This button is marked "A" in Fig. 26, and is called the restoring button.

The receiver circuits beyond the receiver disk will be taken up in connection with the printer. We will now explain the polar duplex operation of the Morkrum System.

POLAR DUPLEX OPERATION. The system of telegraphy as presented in Fig. 24 is capable of duplex operation, that is, capable of simaltaneously transmitting two messages: one in either direction. The plan is that of the polar duplex. As in all duplex schemes, the principal requirement is that the home-main-line relay shall respond only to signals from the distant station, and that the distant-main-line relay shall respond on-

THE WORKING SYSTEM OF PRINTING TELEGRAPHY

the two synchronizing buttons of the transmitter have been combined into one large button on the receiver disk. This button is marked "A" in Fig. 26, and is called the restoring button.

The receiver circuits beyond the receiver disk will be taken up in connection with the printer. We will now explain the polar duplex operation of the Morkrum system.

POLAR DUPLEX OPERATION. The system of telegraphy as presented in Fig. 24 is capable of duplex operation, that is, capable of simultaneously transmitting two messages: one in either direction. The plan is that of the polar duplex. As in all duplex methods, the principal requirement is that the home-main-line relay shall respond only to signals from the distant station, and that the distant-main-line relay shall respond on-

ly to signals from the home station. In other words, each relay registers signals received from the other station, but does not register signals sent out from its own station. If the relays perform in such a manner, then each station can simaltaneously receive and transmit a message without the interference of the line signals.

The circuits essential for duplex operation have been separated from the general scheme of Fig. 24, and are presented in Fig. 27. This figure represents two stations, exactly alike. Suppose the main line pole changer at the home station to be on its positive contact, as shown in the figure. A circuit is thereby established from ground at G', through the positive leg of the main line battery, B, through the pole changer contact, to the middle point of the

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

ly to signals from the home station. In other words, each relay registers signals received from the other station, but does not register signals sent out from its own station. If the relays perform in such a manner, then each station can simultaneously receive and transmit a message without the interference of the line signals.

The circuits essential for duplex operation have been separated from the general scheme of Fig. 84, and are presented in Fig. 87. This figure represents two stations, exactly alike. Suppose the main line pole changer at the home station to be on its positive contact, as shown in the figure. A circuit is thereby established from ground at G', through the positive leg of the main line battery, B, through the pole changer contact, to the middle point of the

milammeter winding; at this point, the path divides into two branches. One part leads through one coil of the main line relay, through the artificial line, to ground at G_1. The other part goes through the other coil of the main line relay, through the line to the distant station, through one coil of the main line relay, through the entire milammeter winding, then through the second coil of the main line relay to the artificial line, and through that to ground. Now, return to the middle point of the milammeter at the home station; the current path divides at this point. If the artificial line is properly adjusted, the resistance and capacity to ground through the two branches of the circuit will be the same. Hence, the current divides here into two equal parts, and, moreover, the two parts build up to their

THE MORKRUM SYSTEM OF DUPLEXED TELEGRAPHY

millammeter winding; at this point, the path divides into two branches. One part leads through one coil of the main line relay, through the artificial line, to ground at G'. The other part goes through the other coil of the main line relay, through the line to the distant station, through one coil of the main line relay, through the entire millammeter winding, then through the second coil of the main line relay to the artificial line, and through that to ground. Now, return to the middle point of the millammeter at the home station; the current path divides at this point. If the artificial line is properly adjusted, the resistance and capacity to ground through the two branches of the circuit will be the same. Hence, the current divides here into two equal parts, and, moreover, the two parts build up to their

working values at the same rate. Therefore, one-half of the current goes out over the line to the distant station, and one-half goes to ground at the home station. Hence, there are equal currents in the two coils of the home main line relay; the coils are so connected that the two equal currents neutralize each other's magnetic effects. There is, therefore, no resultant movement of the armature. At the receiving or distant station, the currents pass through the relay coils in opposite directions. Hence, the magnetic effects of the currents are additive, and there is a movement of the relay armature. Of course, if the armature is already in the position to which the line current ends to move it, there can be no movement.

Also note that the current at

THE MORRUM SYSTEM OF MINING CHARTERING

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Also note that the current at

the home station passes through the milammeter windings in opposite directions, so that no deflection of the instrument is produced. At the receiving station, however, the current passes through the entire winding in one direction, so that a deflection is produced.

Hence, as a summary of the operations, we may say that signals transmitted by the home station do not affect the receiving apparatus at that station, but are registered by the receiving apparatus at the distant station. In the same way, signals sent out by the distant station affect only the receiving apparatus at the opposite end of the line. The operation of the plan would of course have worked out the same had both stations been sending out either positive or negative currents.

THE MORSE SYSTEM OF PLOTTING T.TELEGRAPHY

the home station passes through the mirror-meter windings in opposite directions, so that no deflection of the instrument is produced. At the receiving station, however, the current passes through the entire winding in one direction, so that a deflection is produced.

Hence, as a summary of the operations, we may say that signals transmitted by the home station do not affect the receiving apparatus at that station, but are registered by the receiving apparatus at the distant station. In the same way, signals sent out by the distant station affect only the receiving apparatus at the opposite end of the line. The operation of the plan would of course have worked out the same had both stations been sending out either positive or negative currents.

If both stations are sending out currents of the same sign, say positive for example, we have equal e.m.f's. impressed on both ends of the line. Hence, there is no resultant line current, and of course, no current through those coils of the main line relays which are connected directly to the line. Each relay will, however, register the same as though it were receiving current from the other station. An inspection of the diagram will show that the current through the artificial line at the home station will be in the same direction as positive current from the distant station would be. Hence, this current through the one coil of the relay produces the same movement of the armature as a positive current from the other station would produce. Likewise, at the distant station, the current through the arti-

THE MOSAICISM SYSTEM OF PRINTING TELEGRAPHY

If both stations are sending out currents of the same sign, say positive for example, we have equal e.m.f's. impressed on both ends of the line. Hence, there is no resultant line current, and of course, no current through those coils of the main line relays which are connected directly to the line. Each relay will, however, register the same as though it were receiving current from the other station. An inspection of the diagram will show that the current through the artificial line at the home station will be in the same direction as positive current from the distant station would be. Hence, this current through the one coil of the receiver produces the same movement of the armature as a positive current from the other station would produce. Likewise, at the distant station, the current through the arti-

ficial line and one coil of the main line relay is in the same direction as a positive current from the home station. Hence, the movement of the distant relay armature is the same as though that movement were produced by a positive current from the home station. Therefore, we see that each relay still registers the signal sent out by the other station, but does so by current from its own station.

If both stations were sending out negative currents instead of positive, the operations would be exactly the same, except, of course, the relay armatures would take position against the opposite points from the first case.

In case both stations are sending out current, but these currents are of different sign, the operation of the re-

THE MORSE SYSTEM OF TELEGRAPHY

total line and one coil of the main line relay is in the same direction as a positive current from the home station. Hence, the movement of the distant relay armature is the same as though that movement were produced by a positive current from the home station. Therefore, we see that each relay still registers the signal sent out by the other station, but does so by current from its own station.

If both stations were sending out negative currents instead of positive, the operations would be exactly the same, except, of course, the relay armatures would take position against the opposite points from the first case.

In case both stations are sending out current, but these currents are of different sign, the operation of the re-

lays is not changed. The only effect is the doubling of the line currents.

We see, therefore, that by using the instruments and connections of Fig. 27, we can establish duplex operation, that is, we can establish simaltaneous communication in either direction over a single wire.

The Morse sounder and other instruments of Fig. 24 are used when the two distributors are being first put into operation. By means of these instuments, the operators at the two ends of the line can communicate with each other. Since these Morse circuits do not form a part of the printing telegraph system proper, their discussion will be omitted.

We will now take up the description of the only remaining element of

THE MORKRUM SYSTEM OF PRINTING TELEGRAPH

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We see, therefore, that by using the instruments and connections of Fig. 87, we can establish duplex operation, that is, we can establish simultaneous communication in either direction over a single wire.

The Morse sounder and other instruments of Fig. 84 are used when the two distributors are being first put into operation. By means of these instruments, the operators at the two ends of the line can communicate with each other. Since these Morse circuits do not form a part of the printing telegraph system proper, their discussion will be omitted.

We will now take up the description of the only remaining element of

the distribution system, viz., the Wheatstone differential relay.

THE WHEATSTONE DIFFERENTIAL RELAY. The main line pole changer, main line relay, and printer relay, although they do not form a part of the distributor itself, yet constitute part of the entire distribution system; all three are adaptations of the Wheatstone differential relay. The three functions are performed by instruments which are exactly alike in mechanical construction, but differ in their electrical connections.

The Wheatstone differential relay is primarily the same in its action as any other polarized relay; that is, it includes a moving contact arm, playing between two fixed contact points, and operating solenoids. The contact arm takes position against one point or the other, depending upon the direction of the current through the operat-

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THE WHEATSTONE DIFFERENTIAL RELAY. The main line pole changer, main line relay, and printer relay, although they do not form a part of the distributor itself, yet constitute part of the entire distribution system; all three are adaptations of the Wheatstone differential relay. The three functions are performed by instruments which are exactly alike in mechanical construction, but differ in their electrical connections.

The Wheatstone differential relay is primarily the same in its action as any other polarized relay; that is, it includes a moving contact arm, playing between two fixed contact points, and operating solenoids. The contact arm takes position against one point or the other, depending upon the direction of the current through the operat-

ing coils. The armature, however, is not permanently polarized, as it is in the usual form of polarized relay, but is polarized by a separate exciting coil. The relay may be used as a differential or cumulative instrument, depending upon the connections of its operating coils. A relay is said to be differential when the magnetic effects of the currents through its operating coils counter-balance or oppose each other, and cumulative when the magnetic effects of all currents add to each other. The Wheatstone differential relay in its working form is shown in the accompanying plates.

The principal parts of the instrument are shown in Fig. 28. The two cores of the main coils, C and C', are mounted vertically and side by side. On these cores are wound the main coils, each coil

THE MOSKRUM SYSTEM OF PRINTING TELEGRAPHY

cores are wound the main coils, each coil being vertically and side by side. On these cores of the main coils, C and C', are mounted two coils. The armature, however, is not permanently polarized, as it is in the usual form of polarized relay, but is polarized by a separate exciting coil. The relay may be used as a differential or cumulative instrument, depending upon the connections of its operating coils. A relay is said to be differential when the magnetic effects of the currents through its operating coils counter-balance or oppose each other, and cumulative when the magnetic effects of all currents add to each other. The Hasbrouck differential relay in its working form is shown in the accompanying plates.

The principal parts of the instrument are shown in Fig. 28. The two

consisting of two separate windings. The ends of the windings are brought out to binding posts on the base of the instrument. Each core is fitted with pole-pieces, as is indicated.

The armatures, A and A', play between the pole pieces, one armature being at the top of the cores and the other at the bottom. Each armature consists of an iron disk with a small projecting tongue at one edge. The two disks are attached to a brass rod, R, which runs through the centers of the disks; brass is selected for this rod on account of its non-magnetic properties. The rod is supported at the top and bottom in pivots. The tongues af the armatures extend into the space between pole-pieces.

The exciting coil may also

THE MORSE SYSTEM OF PRINTING TELEGRAPHY

The exciting coil may also consist of two separate windings. The ends of the windings are brought out to binding posts on the base of the instrument. Each core is fitted with pole pieces, as is indicated.

The armatures, A and A', play between the pole pieces, one armature being at the top of the cores and the other at the bottom. Each armature consists of an iron disk with a small projecting tongue at one edge. The two disks are attached to a brass rod, R, which runs through the centers of the disks; brass is selected for this rod on account of its non-magnetic properties. The rod is supported at the top and bottom in pivots. The tongues of the armatures extend into the space between pole-pieces.

be seen in Fig. 28. As shown, the coil comprises an iron core, upon which is placed the exciting winding. The core is mounted vertically, and is of about the same height as the other cores; at the top and bottom, the core is fitted with pole-pieces.

The pole-pieces are end pieces, attached to the core in such a manner that they project from one side of the core. Semi-circles are cut out of the projecting ends of these pole-pieces; in the two semi-circular pockets so formed are placed the two circular disk-ends of the armatures, one disk being placed in each pole-piece. A very small air-gap is left between the armatures and pole-pieces, so that the two armatures and the brass connecting rod by which they are supported can turn freely in their pivots.

Just above the upper armature, and mounted on the brass connecting

THE MONKMAN SYSTEM OF PRINTING TELEGRAPHY

be seen in Fig. 25. As shown, the coil consists an iron core, upon which is placed the exciting winding. The core is mounted vertically, and is of about the same height as the other cores; at the top and bottom, the core is fitted with pole-pieces.

The pole-pieces are and pieces, attached to the core in such a manner that they project from one side of the core. Semi-circles are cut out of the projecting ends of these pole-pieces; in the two semicircular pockets so formed are placed the two circular disk-ends of the armature, one disk being placed in each pole-piece. A very small air-gap is left between the armature and pole-pieces, so that the two armatures are supported can turn freely in their pivots. and the brass connecting rod by which they

Just above the upper armature, and mounted on the brass connecting

rod, R, is a contact arm, O. This arm is fixed to the rod, R, at one end, and carries a contact point at its other extremity. Two fixed contact points are provided, one on either side of the arm and both in line with the contact point carried by the arm. The arm swings back and forth with the armatures between the two stationary points.

As for the operation of the relay, suppose the two operating coils carry currents which polarize the poles and cores in the manner indicated in Fig. 29. Also, let the current in the armature-exciting coil be of the direction that polarizes the armatures as shown. There is no return path for the exciting coil flux between armatures except through the intervening air or through the cores of the operating coils; obviously, the flux chooses the latter path. Hence, in Fig.

THE MOSCRUM SYSTEM OF PRINTING TELEGRAPHY

rod, R, is a contact arm, C. This arm is fixed to the rod, R, at one end, and carries a contact point at its other extremity. Two fixed contact points are provided, one on either side of the arm and both in line with the contact point carried by the arm. The arm swings back and forth with the armatures between the two stationary points.

As for the operation of the relay, suppose the two operating coils carry currents which polarize the poles and cores in the manner indicated in Fig. 80. Also, let the current in the armature-exciting coil be of the direction that polarizes the armatures as shown. There is no return path for the exciting coil flux between armatures except through the intervening air or through the cores of the operating coils; obviously, the flux chooses the latter path. Hence, in Fig.

18, the flux between armatures assumes the same direction and path as the operating flux. Such action pulls the armature in the direction of the flux; that is, the armature takes position against the right-hand pole-piece. When the armatures are in this position, the contact arm lie against the right-hand contact point.

Had the operating current been in the opposite direction, the cores, C and C', and their pole-pieces would have been oppositely polarized. Hence, the armatures would have swung toward the left pole-pieces until the swinging contact arm made contact with the stationary point at the left side. Therefore, the direction of the working current, by determining the polarity of the pole-pieces, determines to which side the armatures will swing, and therefore

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

18. The flux between armatures assumes the same direction and path as the operating flux. Each section pulls the armature in the direction of the flux; that is, the armature takes position against the right-hand pole-piece. When the armatures are in this position, the contact arm lie against the right-hand contact point.

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determines whether the right- or left-hand contact will be closed.

If, instead of the direction of the working current being changed, the direction of the armature exciting current had been changed, the armature would have changed position just the same. This movement would be due to the change in the polarity of the armatures. In practice, however, the exciting current of the armature is not changed.

In Fig. 30 are shown the three methods of connecting the relay windings when the instrument is to perform its three respective functions. As was said before, each core carries two independent windings, all four windings being the same; the windings on each core are shown separated in Fig. 30, but in reallity, both are distributed over the entire length of the core.

THE MORRUM SYSTEM OF RAISING RELIGRAPHS

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In Fig. 30 are shown the three methods of connecting the relay windings when the instrument is to perform its three reciprocative functions. As was said before, each core carries two independent windings, all four windings being the same; the windings on each core are shown separated in Fig. 30, but in reality, both are distributed over the entire length of the core.

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

In Fig. 30(a) is shown the relay as connected for action as a main line pole changer. In this case, all four windings are in series, and in such a way that their magnetic effects are cumulative. The external connections are to terminals a and b. An application of the cork-screw rule shows that when the coils carry current in the direction indicated by the arrows, the top of the left core becomes a north pole, whereas the top of the right-hand core becomes a south pole. The contact arm, therefore, assumes position against the right-hand contact point. If the operating current is reversed, the polarity of the cores is reversed and the contact arm assumes position against the left point. Hence, the instrument fulfills the requirements of a main line pole changer.

In Figs. 30(b and c), we see

DUAL MONARCH SYSTEM OF PRINTING TELEGRAPHY

In Fig. 30(a) is shown the relay as connected for action as a main line pole changer. In this case, all four windings are in series, and in such a way that their magnetic effects are cumulative. The external connections are to terminals a and b. An application of the cork-screw rule shows that when the coils carry current in the direction indicated by the arrows, the top of the left core becomes a north pole, whereas the top of the right-hand core becomes a south pole. The contact arm, therefore, assumes position against the right-hand contact point. If the operating current is reversed, the polarity of the cores is reversed and the contact arm assumes position against the left point. Hence, the instrument fulfills the requirements of a main line pole changer.

In Figs. 30(b and c), we see

the instrument arranged for operation as a main line relay. The main line relay is under the action of two operating currents: that passing through the artificial line, and that passing through the main line. These two currents should neutralize each other's effects on the armature. At the same time, the relay should respond to a single operating current passing through all windings in series. An examination of Fig. 30(b and c) will show that the relay will act in the desired manner. Fig. 30(b) shows the relay carrying currents that neutralize, that is, the currents which it carries when messages are being transmitted from its own station. Fig. 30(c) shows the instrument carrying a single operating current, as it does when messages are being received.

In Fig. 30(d) is shown the

THE MORSE SYSTEM OF PRINTING TELEGRAPHY

In Fig. 30(a) is shown the instrument arranged for operation as a main line relay. The main line relay is under the action of two operating currents: that passing through the artificial line, and that passing through the main line. These two currents should neutralize each other's effects on the armature. At the same time, the relay should respond to a single operating current passing through all windings in series. In examination of Fig. 30(b and c) will show that the relay will act in the desired manner. Fig. 30(b) shows the relay carrying currents that neutralize, that is, the currents which it carries when messages are being transmitted from its own station. Fig. 30(c) shows the instrument carrying a single operating current, as it does when messages are being received.

relay connected for use as a printer relay. In this case, there should be two sets of windings; current through one set should cause the armature to take position against one point, whereas current through the other set should cause the armature to take position against the other point. Two windings are therefore provided, each consisting of two coils, one on each core. The terminals of one winding are a and b; the terminals of the other are b and c. Terminal b goes to one side of the operating battery. Now, if terminal a is connected to the remaining side of the battery, the armature assumes position adjacent to the left pole-piece. If, instead, terminal c is connected to the remaining side of the battery, the armature shifts to the right-hand position. Hence, the position of the armature depends upon which of its two

THE MORSE SYSTEM OF PRINTING TELEGRAPHY

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windings is energized; this is the action desired in the printer relay. It should be noted that the windings are not energized simaltaneously, but only one at a time.

In Fig. 24, conventional symbols are used for the differential relays in the different functions. In the diagram, each instrument is shown as having two coils, just as the usual type of polarized relay. However, if it is remembered that the Wheatstone differential relay always has two coils, though they may be on the same or different cores, and that changes in the operating currents in these coils produce exactly the same effects as the same changes would produce in an ordinary polar relay, no confusion on the part of the reader will result. In the wiring diagram, the armature-exciting coils are omitted for the sake of simplicity.

THE MORSE SYSTEM OF PRINTING TELEGRAPHY

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THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

The last paragraph concludes the discussion of the distribution system. Next will come a description of the printer. As in the foregoing material, rough sketches of the printer parts will be used to show the general principle of action, whereas the photographs of the actual machine will be relied upon to show the detailed construcion of the machine.

THE MOTHOUN SYSTEM OF PRINTING TYPEWRITER

The last paragraph concludes the discussion of the distribution system. Next will come a description of the printer. As in the foregoing material, rough sketches of the printer parts will be used to show the general principle of action, whereas the photographs of the actual machine will be relied upon to show the detailed construction of the machine.

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

Part IV - The Printer.

GENERAL. The Morkrum printer is, in reallity, a typewriter, operated by electro-magnets ,which are controlled by the incoming line impulses. In the following description of the machine, the plan will be to take up first the mechanical movements of the printer, and then to explain the electrical means by which the mechanical movements are operated and controlled.

The complete printer may be seen in the accompanying plates. As is indicated, the main frams consists of a bed-plate, from each corner of which rises a post; a cover-plate is screwed onto the top of these posts. When the machine is completely assembled, it is entirely enclosed except for the platen and typewheel carriage.

The printing action in this machine is accomplished by the typewheel striking a message blank, which is supported

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

Part IV - The Printer.

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The complete printer may be seen in the accompanying plates. As is indicated, the main frame consists of a bed-plate, from each corner of which rises a post; a cover-plate is screwed onto the top of these plate, it is entirely enclosed except for the posts. When the machine is completely assembled, it is entirely enclosed except for the platen and typewheel carriage.

The printing action in this machine is accomplished by the typewheel striking a message blank, which is supported

on the platen. These parts are shown in the assembly photographs.

THE TYPEWHEEL. The typewheel is shown in Fig. 31. It is a fiber drum, around the edge of which occur the type in raised characters; the characters are arranged in two rows, one near the top and one near the bottom of the drum. The typewheel has a hub at its center, the hub being bored to fit a shaft called the typewheel shaft. This shaft furnishes the primary support for the wheel.

THE PLATEN. The platen is a rubber roller, whose purpose is to hold the message blank or other paper. It is similar to a typewriter platen, and will be taken up in detail a little later.

THE TYPEWHEEL MOVEMENTS. There are a number of necessary movements of the typewheel. Primarily, of course, the wheel

THE MORKRUM SYSTEM OF PRINTING TYPEWRITER

on the platen. These marks are shown in the assembly photograph.

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THE TYPEWHEEL MOVEMENTS. There are a number of necessary movements of the typewheel. Primarily, of course, the wheel

must strike the platen so as to print the character. Before this action, however, it must have rotated so that when it strikes, the proper proper raised character will be at the point of contact between the wheel and platen. Also, the typewheel must be in its correct vertical position, that is, the correct position along the axis of its shaft. If the wheel is in its normal position, characters of the top row strike the platen; if the wheel be raised a little, characters of the bottom row strike the platen. This latter is called the shift position of the wheel, and is assumed when the shift signal is received over the line. Furthermore, after the printing of each letter, the typewheel must be spaced, that is, it must be moved along in front of the platen a short distance, so that the next letter printed will lie beside

THE MONARCH SYSTEM OF PRINTING TELEGRAPHY

that the next letter printed will lie beside in front of the platen a short distance, so be spaced, that is, it must be moved along printing of each letter, the typewheel must ceived over the line. Furthermore, after the and is assumed when the shift signal is re- ter is called the shift position of the wheel, the bottom row strike the platen. This let- the wheel be raised a little, characters of sectors of the top row strike the platen; if If the wheel is in the normal position, char- correct position along the axis of its shaft. its correct vertical position, that is, the and platen. Also, the typewheel must be in at the point of contact between the wheel character. Before this action, however, it must have rotated so that when it strikes, the proper proper raised character will be must strike the platen so as to print the

the preceeding one. It is important that we note that in this printer, the platen remains stationary, whereas the typewheel travels back and forth in front of the platen, and thereby distributes the successive characters along the printed line; in the ordinary typewriter, the platen carries the paper before the point of printing, but in this case, it is the printing point which moves. And last, when the end of a printed line is reached, the typewheel must be moved back to its starting position. With this idea of the typewheel movements, we are now ready to study the means by which these movements are accomplished.

THE CARRIAGE. The typewheel is supported on a carriage (see Fig. 32). The carriage travels back and forth before the platen, carrying the typewheel with it. As is indicated in the general views, the car-

THE MECHANISM SYSTEM OF THE TYPEWRITING MACHINE

is indicated in the general views, the carriage, carrying the typewheel with it. As carriage travels back and forth before the platen, the typewheel is supported on a carriage (see Fig. 82). The

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riage is supported on two square steel rods, which extend clear across the front of the printer just in front of the platen. The carriage is so constructed that when one of the rods is turned, the typewheel strikes the platen, when the other rod is turned, the typewheel assumes the shift position. Hence, these rods not only form a run-way or track for the carriage, but also serve to transmit energy to the carriage for the typewheel movements. Because of this arrangement, the electro-magnets operating the typewheel can remain stationary, and be rigidly attached to the frame of the machine. A third rod, similar to the other two, but not assisting in the support of the carriage, is located below the other two rods. This third rod serves to transmit the motion of rotation to the typewheel. We see, therefore, that the car-

THE MORRIS SYSTEM OF PRINTING MECHANISM

riage is supported on two square steel rods, which extend clear across the front of the printer, just in front of the platen. The carriage is so constructed that when one of the rods is turned, the typewheel strikes the platen, when the other rod is turned, the typewheel assumes the shift position. Hence, these rods not only form a two-way or tread for the carriage, but also serve to transmit energy to the carriage for the typewheel movements. Because of this arrangement, the electro-magnets operating the typewheel can remain stationary, and be rigidly attached to the frame of the machine. A third rod, situated to the other two, but not meshing in the support of the carriage, is located below the other two rods. This third rod serves to transmit the motion of rotation to the typewheel. We see, therefore, that the car-

riage serves as a support for the typewheel, and also transmits to the wheel the movements of rotating, striking, and shifting.

The complete carriage is shown in Fig. 32. As the mechanism is rather complicated, we will take up, one at a time, its various functions and the parts concerned.

The carriage frame is shown in Fig. 33. It consists of two parts. The first is a yoke, which is supported by the two steel rods as stated before. The yoke is fitted with round collars, free to turn, which have square holes at their centers; the holes fit the square supporting rods, so that when the rods are turned, the collars turn with them. The second part of the casting is of the form shown; it is attched to the yoke by two small shafts in the bearings.

GUN MOUNTING SYSTEM OF LIGHTING TELEGRAPHY

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THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

In Fig. 34, we see the essential parts for rotating the typewheel. The bevel gear, B, is mounted on the lower end of a vertical shaft, S; at the top of the shaft is a universal joint. A sleeve, A, is attached to the upper member of the universal joint, and into this sleeve slides the typewheel shaft, F. The upper end of the shaft carries an arm, called the locating arm, which locates the typewheel. The typewheel is set onto its shaft with the locating arm extending into one of the holes in the bottom of the wheel. The shaft, F, is attached to the collar, C, which fits over the sleeve, A. The collar, C, and the shaft, F, are joined by a small pin, D, so that the the collar and shaft can move up and down along the sleeve, A. This mounting is necessary in order that the typewheel may move to

THE MOUNTING SYSTEM OF MILLING MACHINERY

In Fig. 34, we see the essential parts for rotating the typewheel. The bevel gear, E, is mounted on the lower end of a vertical shaft, S; at the top of the shaft is a universal joint. A sleeve, A, is attached to the upper member of the universal joint, and into this sleeve slides the typewheel shaft, F. The upper end of the shaft carries an arm, called the locating arm, which locates the typewheel. The typewheel is set onto its shaft with the locating arm extending into one of the holes in the bottom of the wheel. The shaft, F, is attached to the collar, C, which fits over the sleeve, A. The collar, C, and the shaft, F, are joined by a small pin, D, so that the collar and shaft can move up and down along the sleeve, A. This mounting is necessary in order that the typewheel may move to

the shift position and may still be rotated. The purpose of the universal joint is to allow the typewheel to strike without disturbing the gear, B, and the shaft, S.

Fig. 34 also shows the method by which motion is transmitted from the rotator shaft to the gear, B. A second gear, E, meshes with the gear, B; this second gear, E, has a square hole cut in its center, so that it fits over the square rotator shaft. Hence, when the rotator shaft is turned, the gear, E, is also turned, so that the typewheel rotates. The gear, E, fits the rotator shaft loosely, so that the gear can slide along the shaft with the carriage, and be in mesh with the gear, B.

In Fig. 32, we see the rotator parts in place on the carriage frame. As is indicated, the second casting of the car-

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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Fig. 84 also shows the method by which motion is transmitted from the rotator shaft to the gear, B. A second gear, E, meshes with the gear, B; this second gear, E, has a square hole cut in its center, so that it fits over the square rotator shaft. Hence, when the rotator shaft is turned, the gear, E, is also turned, so that the typewheel rotates. The gear, E, fits the rotator shaft loosely, so that the gear can slide along the shaft with the carriage, and be in mesh with the gear, B.

In Fig. 82, we see the rotator parts in place on the carriage frame. As is indicated, the second casting of the car-

riage serves to support the sleeve, whereas the lower casting holds the shaft, F, of Fig. 34. Fig. 32 also shows the gear guide, by which the gear, E, is drawn along with the carriage. As indicated, the lower casting carries an arm extending downward, and this arm supports a collar bearing for the gear E of Fig. 34.

The striker movement of the carriage is shown clearly in Fig. 32, left view. To the collar, which fits over the striker shaft, is attached a lever, #25-4, the upper end of which is connected by a link, #25-5, to the upper casting of the carriage frame. Hence, when the rotator shaft turns (to the left), it turns the lever, #25-4, which movement pushes the typewheel to the left and downward. The carriage in this latter position is shown in Fig. 39.

THE MORKRUM CYCLOPEDIA OF PRINTING TECHNOLOGY

rings serve to support the sleeve, whereas the lower casting holds the shaft, F, of Fig. 34. Fig. 32 also shows the gear guide, by which the gear, E, is drawn along with the carriage. As indicated, the lower casting carries an arm extending downward, and this arm supports a collar bearing for the gear E of Fig. 34.

The striker movement of the carriage is shown clearly in Fig. 32, left view. To the collar, which fits over the striker shaft, is attached a lever, 32B-4, the upper end of which is connected by a link, 32B-5, to the upper casting of the carriage frame. Hence, when the rotator shaft turns (to the left), it turns the lever, 32B-4, which movement pushes the typewheel to the left and downward. The carriage in this latter position is shown in Fig. 39.

Note that the joint between the carriage-frame castings is in line with the universal joint of the typewheel shaft; hence, the carriage can bend over like a hinge.

A centering device is added to the striker movement of the carriage in order that the raised characters of the typewheel will always hit the paper squarely. Onto the typewheel shaft is attached a star-wheel, #25-14 (see Figs. 32, 35, and 36); the star-wheel is so placed that the spaces between its teeth lie directly below the respective characters on the typewheel. A centering lever, #25-19, is mounted on the carriage frame as shown in Fig. 36. This lever is pivoted, near its middle point, to the carriage frame; the lower end carries a cross-pin, P (Fig. 36), which fits into the slot of a transverse cam. This cam is rigidly attached

THE MONARCH SYSTEM OF BLIND TYPEWRITING

Note that the joint between the carriage-
frame casting is in line with the univer-
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wheel, ¾28-14 (see Figs. 32, 33, and 36);
the star-wheel is so placed that the spaces
between its teeth lie directly below the re-
spective characters on the typewheel. A cen-
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riage frame as shown in Fig. 36. This lever
is pivoted, near its middle point, to the
carriage frame; the lower end carries a cross-
pin, 7 (Fig. 36), which fits into the slot of
a transverse cam. This cam is rigidly attached

to the lower casting of the carriage. Ordinarily, the centering lever is in the position shown in Fig. 35, but as the carriage is bent over for the striking movement, the relative motion of the cam and centering lever is such that the upper end of the centering lever enters one of the spaces between the teeth of the star-wheel. Both the upper end of the centering lever and the spaces in the star-wheel are slightly V-shaped. Hence, as the lever enters the space, the star-wheel and typewheel are not only brought to center, but are looked in that position until the end of the stroke. The parts are returned to their original positions through a reversal of rotation of the striker shaft.

The shift mechanism may be understood from Fig. 32. The collar which fits over the shift shaft carries an arm, A.

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

to the lower casting of the carriage. Gradually, the centering lever is in the position shown in Fig. 35, but as the carriage is bent over for the striking movement, the relative motion of the cam and centering lever is such that the upper end of the centering lever enters one of the spaces between the teeth of the star-wheel. Both the upper end of the centering lever and the spaces in the star-wheel are slightly V-shaped. Hence, as the lever enters the space, the star-wheel and typewheel are not only brought to center, but are locked in that position until the end of the stroke. The parts are returned to their original positions through a reversal of rotation of the striker shaft.

The shift mechanism may be understood from Fig. 32. The roller which fits over the shift shaft carries an arm, A.

By means of a link, this arm connects with the vertical sliding rod marked "shift plunger". This rod slides up and down in the bearings on the main casting as is shown in the figure. To this rod is attched the clutch, #25-7, which is merely a flat plate. One end of the plate is attached to the plunger rod; the other end is forked, and fits over the end of the collar (C of Fig. 34) on the typewheel shaft.

When the shift shaft is turned (to the left), it turns the sleeve and the arm, A. This movement raises the plunger, #25-42, which movement, in turn, raises the clutch collar, typewheel shaft, and typewheel. The typewheel is thereby moved into the shift position.

A return spring on the carriage brings the parts of the shift mechanism, including the shift shaft, back to their normal

THE MODERN SYSTEM OF PRINTING TELEGRAPHY

By means of a link, this arm connects with the vertical sliding rod marked "shift plunger". This rod slides up and down in the bearings on the main casting as is shown in the figure. To this rod is attached the clutch, 28-V, which is merely a flat plate. One end of the plate is attached to the pl nger rod; the other end is formed, and fits over the end of the collar (C of fig. 24) on the typewheel shaft.

When the shift shaft is turned (to the left), it turns the sleeve and the arm, A. This movement raises the plunger, 28-42, which movement, in turn, raises the clutch collar, typewheel shaft, and typewheel. The typewheel is thereby moved into the shift position.

A return spring on the carriage pushes the parts of the shift mechanism, including the shift shaft, back to their normal

inoperative position. This spring is shown in Fig. 32; it is stretched between the spring bracket, #25-10, on the plunger, to the lower part of the carriage casting.

The inker is the device by which ink is smeared onto the typewheel face during the striking movement; the ink is applied just before the wheel strikes the platen. The inker consists of a small felt roller, soaked in ink, and mounted on supporting levers. These levers are attched to the frame of the carriage. As this device is mechanically simple and unimportant, it is omitted from the detail drawings; it is shown, however, on the assembly photographs.

THE ROTATOR, STRIKER, AND SHIFT LINKS. The means for turning the rotator, striker, and shift shafts are shown in Fig. 37. This figure also shows the method of supporting the shafts on the main bear-

THE MODERN SYSTEM OF PRINTING TELEGRAPHS

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THE ROTATOR, STRIKER, AND

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The inker is the device by

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in Fig. 32; it is stretched between the spring
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ing plates.

THE ROTATOR LINKS. Considering the rotator mechanism first, we see that the rotator magnets, which furnish the energy for rotating the typewheel, are located at the bottom of the machine near the middle of the base. There are two sets of magnets: one set for left and one set for right rotation of the typewheel. Each set consists of two solenoids, allfour being supported from the base by the magnet bracket. Each solenoid is fitted with a sliding core or plunger; the two plungers of the left rotator magnets are joined by a yoke attached at their ends, and likewise, the two plungers of the right rotator magnets are connected by a similar yoke. From the center of each yoke, a rod, R, comes forward between the two solenoids, passes through a guide hole in the magnet bracket,

THE MOTOROLA SYSTEM OF PRINTING TELEGRAPHY

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THE ROTATOR LINKS. Considering the rotator mechanism first, we see that the rotator magnets, which furnish the energy for rotating the typewheel, are located at the bottom of the machine near the middle of the base. There are two sets of magnets: one set for left and one set for right rotation of the typewheel. Each set consists of two solenoids, either being supported from the base by the magnet bracket. Each solenoid is fitted with a sliding core or plunger; the two plungers of the left rotator magnets are joined by a yoke attached at their ends, and likewise, the two plungers of the right rotator magnets are connected by a similar yoke. From the center of each yoke, a rod, R, comes forward between the two solenoids, passes through a guide hole in the magnet bracket,

and terminates in a rounded end at some distance in front of the bracket. Each rod is fitted with a collar near its projecting end, and an open-coil compression spring is placed between the collar and the bracket. We come now to the connecting links between the rotator magnets and the rotator shaft.

The connecting links comprise first, an auxiliary shaft, called the magnet shaft. This shaft is supported at one end in a bearing in the magnet bracket, and at the other end in a bearing in the main right bracket. At the end near the rotator coils, the shaft carries a cross-bar, C, and near the other end, the sector of a gear. In Fig. 37, this sector is shown considerably to the left of the right main bracket; in reallity, the sector lies very close to that bracket. The cross-bar, C, extends in front of both

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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The cross-bar, C, extends in front of both

rods, RR; the springs on the rods keep the rods firmly against the cross-bar. The gear sector stands vertically on the magnet shaft, and engages with a pinion of the rotator shaft.

The operation of the scheme is as follows: If the right rotator magnets be energized, they draw their plungers forward; this action thrusts the upper rod, R, forward, and with it, the upper end of the cross-bar, C. Hence, the auxiliary or magnet shaft turns through a small angle, and with it, the gear sector; the movement of the gear sector turns the pinion meshed with it, and in that way turns the rotator shaft. If the left rotator magnets had been energized instead of the right, the rotator shaft would have been turned in the opposite direction.

Means are provided for returning the parts to their original positions

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Means are provided for returning the parts to their original positions

after the rotator magnets have been de-energized. A small arm, called a centering arm, is attched to the magnet shaft at the outside of the right main bracket. This arm points downward. At its lower end are attached two closed-coil tension springs, called centering springs. The other ends of the springs are attached to anchor lugs on the main bracket, one lug being at the left and one at the right of the arm. The right-hand spring is attched to its lug by means of an adjustable screw, so that the tension of the springs can be varied by the turning of the screw. By this arrangement, the two springs tend to draw the arm in opposite directions, one toward the right, and theother toward the left. Since the springs are equal in strength, there is no displacement of the arm from its central position. If, however,

THE NORMUM SYSTEM OF PRINTING TYPEWRITING

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a rotating movement of the typewheel occurs, the centering arm turns with the magnet shaft, thereby drawing out one centering spring and releasing the other. When the rotation magnets are de-energized, thus releasing the torque on the magnet shaft and centering arm, the springs draw the centering arm back to its vertical position. This movement of the arm brings all the rotator parts back to their central positions.

The centering device just described has proven to be inadequate for rapid working of the printer. All the parts should be centered after one letter has been printed and before the next has begun. When the letters are printed in rapid succession, the centering mechanism does not work fast enough. The action of the springs diminishes as the central position of the arm is ap-

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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The centering device just described has proven to be inadequate for rapid working of the printer. All the parts should be centered after one letter has been printed and before the next has begun. When the letters are printed in rapid succession, the centering mechanism does not work fast enough. The action of the springs diminishes as the central position of the arm is ap-

proached, because the working spring is nearly counter-balanced by the other. Therefore, a second centering mechanism has been added; this latter device acts on the rotator shaft itself, and does not come into very great action until the parts have nearly reached their central positions.

The second centering mechanism may be seen in Fig. 37. The rotator shaft projects through the main bracket on the right; the shaft is here fitted with a small semi-circular cam, D. Two small bell cranks are mounted at their elbows on the bracket as shown.One end of each crank bears against the flat face of the cam, whereas the two free ends are connected by an open-coil tension spring. The centering action of the device is apparent from Fig. 37. Note that the action increases as the central position of

THE MORRUM SYSTEM OF PRINTING TELEGRAPHY

action increases as the central position of the device is approached from fig. 87. Note that the two ends are connected by an open-coil tension spring. The centering action of the device is apparent from fig. 87. Note that the flat face of the cam, whereas the two shown.One end of each crank bears against mounted at their elbows on the bracket so circular cam, D. Two small ball cranks are the shaft is here fitted with a small semi- projects through the main bracket on the right; ism may be seen in fig. 87. The rotator shaft section until the parts have nearly reached their central positions.

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the parts (the position shown in Fig. 37) is approached. This increase is due to an increase of the effective radius of the restoring torque, which increase accompanies the restoring movement of the parts.

A locking cam is also shown on the rotator shaft, just behind the centering cam; the lock, of which this cam forms a part, must be released before the rotation of the shaft can take place. The purpose and action of this lock will be explained later.

THE STRIKER LINKS. The striker rigging is also shown in Fig. 37. The striker magnet is located at the bottom of the machine beside the left main bracket. The armature is suspended from the lever, L, which is pivoted ed at its lower end to the left main bracket, and attached at its upper end to the connecting rod, E. The upper end of the rod, E,

THE MORRISON SYSTEM OF PRINTING TELEGRAPH

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necting rod, E. The upper end of the rod, K,

is joined to a crank, F, on the striker shaft. The connecting rod contains an adjusting link by which the length of the rod can be varied; this adjustment determines the magnitude of the impact as the typewheel strikes the platen.

When the striker magnet is energized, it draws its armature downward, and with the armature, the lever, L. The movement of the lever, L, turns the striker shaft by means of the connecting rod, E, and turns the crank, F. The crank, F, is mounted on the striker shaft, so that the rotation is transmitted to this shaft.

In order that the striker shaft and other parts shall be restored to their original positions after the stroke, a crank, T, and return spring are provided. The crank is mounted on the right end of the

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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striker shaft, so that the rotation is transthe crank, T. The crank, T, is mounted on the by means of the connecting rod, R, and turns ment of the lever, L, turns the striker shaft and with the armature, the lever, L. The movemerged, it draws its armature downward. When the striker magnet is

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striker shaft. The return spring is an open-coil tension spring, stretched between the crank, T, and an anchor lug on the main bracket. The turning of the striker shaft and crank T from the inoperative position stretches the return spring; hence, at the end of each stroke, as soon as thestriker magnets are de-energized, the return spring draws the parts back to their original position.

THE SHIFT LINKS. The shift mechanism is illustrated in Fig. 37. The shift magnet is attached to a bracket at the left of the rotator bracket. The magnet consists of a solenoid with a plunger core; as we shall see later, the magnet is also a relay. A plunger rod is fixed to the core, passes through a guide hole is the bracket, and terminates in a rounded end. This plunger rod bears against a crank, G, which is mounted on a small shaft,

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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H. At the left end of this shaft is mounted the crank, I, bent to clear the striker magnet as shown. The crank, I, is connected to the crank, J, on the shift shaft, by the connecting rod, P.

When the shift magnet is energized, it draws in its plunger core, and in so doing, thrusts its plunger rod forward. This movement of the plunger rod turns the crank, G, the shaft, H, and the crank, I, Through the agency of the connecting rod, the movement of the crank, I, turns the crank, J, and the shift shaft.

As for the return of the parts to their original positions, it will be remembered that on the carriage, there is a shift return spring. This spring not only acts on the carriage parts, but in so doing, returns the shift shaft and all the rigging

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As for the return of the parts to their original positions, it will be remembered that on the carriage, there is a shift return spring. This spring not only acts on the carriage parts, but in so doing, returns the shift shaft and all the rigging

back to the starting position.

THE SHIFT LOCK. A lock, which locks all the parts in the shift position, is also indicated in the figure. This lock consists of a T-shaped double crank, pivoted at the point of intersection of its three arms on a lug attached to the magnet bracket. The stem of the T extends forward, and contains a notch on its under side; this notch hooks over the end of a vertical lever, K, mounted on the shaft, H. The upper arm of the double crank is held away from the magnet bracket by an open coil compression spring. The lower arm lies in the path of a plunger, which is attached to the plunger core of a solenoid. This solenoid is called the release magnet.

In the operation of the device, the notch in the forward lever is or-

THE MORKUM SYSTEM OF SHUNTING TELEGRAPH

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THE SHIFT LOCK. A lock, which is also indicated in the figure. This lock consists of a T-shaped double crank, pivoted at the point of intersection of its three arms on a lug attached to the magnet bracket. The stem of the T extends forward, and contains a notch on its under side; this notch hooks over the end of a vertical lever, K, mounted on the shaft, H. The upper arm of the double crank is held away from the magnet bracket by an open coil compensation spring. The lower arm lies in the path of a plunger, which is attached to the plunger core of a solenoid. This solenoid is called the release magnet.

In the operation of the device, the notch in the forward lever is en-

dinarily not hooked over the end of the lever, K; K is too far toward the front of the machine to engage with the notch. The T-crank does, however, bear against the top of the lever, K, under the action of the compression spring. When the parts assume the shift position, the lever, K, turns back a little, so that the notch in the crank drops over the end of the lever. Therefore, when the shift magnet is de-energized, the lever, K, is not free to return to its original position, but is locked in its new position. Therefore, all the other shift parts are locked. The release of the parts is effected by the release magnet. When this magnet is energized, its plunger rod comes forward, strikes the lower end of the T-crank, and thereby raises the notch off the lever, K. The lever, with the other parts, is therefore free to

THE MONARCH SYSTEM OF SIGNALING TELEGRAPHY

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return to its original position. When the release magnet is de-energized, the T-crank again drops down onto the lever, K, and the parts are once more in the position indicated in Fig. 37.

The purpose of the shift lock is evident when we remember that often several shift characters occur in succession, and it is desirable that the typewheel maintain its shift position throughout the series.

THE SELECTOR MECHANISM. We now pass to the selector mechanism, by which the rotation of the typewheel is stopped at any desired point. It will be remembered that the typewheel characters are distributed around the entire circumference of the wheel, and in order that any particular letter be printed, the typewheel must be stopped in its rotation when that particular letter lies di-

THE MODERN SYSTEM OF PRINTING TELEGRAPHY

return to its original position. Then the release magnet is de-energized, the T-crank again drops down onto the lever, K, and the parts are once more in the position indicated in Fig. 37.

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THE SELECTOR MECHANISM. We now pass to the selector mechanism, by which the rotation of the typewheel is stopped at any desired point. It will be remembered that the typewheel characters are distributed around the entire circumference of the wheel, and in order that any particular letter be printed, the typewheel must be stopped in its rotation when that particular letter lies di-

rectly before the platen. The selector, complete and applied to the machine, is shown in Fig. 38; as is indicated, it is located at the front of the machine beside the right main bracket. The selector mechanism proper is shown in Fig. 39. As the mechanism is somewhat complicated, its general principles will be explained before the description of the actual parts is attempted.

The fundamental idea in the stopping of the rotator shaft is illustrated in Fig. 40. In this figure, we see the rotator shaft carrying an arm or lever, called the index lever. D is a stationary disk containing a number of holes. When the rotator shaft turns, it of course turns the index lever with it, so that this lever sweeps over the face of the disk, D. If the rotation of the shaft is to be stopped at any desired

THE MORKRUM SYSTEM OF INDICATING DISPLACEMENT

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point, a small pin is pushed up through one of the holes of the disk,D, into the path of the index lever. When the lever strikes the pin, rotation stops.

THE DISKS. Such a disk mechanism, with some minor changes, is used to limit rotation in the Morkrum machine; the mechanism as applied to the printer is shown in Fig. 41a and b. Here, there are four thin steel disks, called selector plates, each of which is similar to the disk, D, of Fig. 40. The four disks are arranged in a pile, with a supporting collar running through their centers; this collar is marked "S" in the figures. Each disk may be turned independently through a small angle on the collar, the turning being limited by the plate stops as indicated. At the bottom of each disk is a lug which carries a small pin, P. An arm, A,

THE MORTRUM SYSTEM OF PRINTING TELEGRAPHY

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with a forked end, fits over the pin, P, and at its lower end, is attached to a small supporting shaft, B. A second arm, C, is also mounted on the shaft, and this second arm lies in the path of a plunger rod which is fixed to the plunger core of the plate solenoid. By this arrangement, if the plate solenoid becomes energized, it draws its core forward, and, through the agency of the two arms, C and A, turns the disk from its normal position of Fig. 41(a) to its opposite position of Fig. 41(b). When the plate solenoid is de-energized, all parts return to their original positions under the action of a coil spring, not shown, wound onto the shaft, B.

The method of moving each of the other three disks is identical with the one just described. The arrangement of the links between the solenoids and disks is shown

THE MEMORY SYSTEM OF PRINTING TELEGRAPH

with a forked end, fits over the pin, P, and at its lower end, is attached to a small supporting shaft, S. A second arm, C, is also mounted on the shaft, and this second arm fixed to the plunger core of the plate solenoid. By this arrangement, if the plate solenoid becomes energized, it draws its core forward, and, through the agency of the two arms, C and A, turns the disk from its normal position of Fig. 41(a) to its opposite position of Fig. 41(b). When the plate solenoid is deenergized, all parts return to their original position under the action of a coil spring, not shown, wound onto the shaft, S.

The method of moving each of the other three disks is identical with the one just described. The arrangement of the links between the solenoids and disks is shown

in Figs. 41(c) and 42. The plate solenoids, as shown in Fig. 42, together with certain other solenoids of the printer, are mounted on the large relay bracket, which is attached to the base. The figue is self-explanatory. By this arrangement, any disk may be moved by its plate solenoid, independently of the movements of any of the other disks.

As for the manner in which the disks are used, the index lever of the rotator shaft sweeps over the face of the outside disk (the one shown in Figs. 41), just as the lever of Fig. 40 sweeps over the face of the disk,D. Ordinarily, the index lever is in the central vertical position shown in Fig. 40, but if the rotator shaft be turned, the index lever of course turns with it. The disks are shown in place

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on the printer in Fig. 38.

The construction of the disks is such, as regards the location of the holes, that if each disk is in one extreme angular position or the other, there are two rows of holes through the disks lined up, and only two rows. For instance, if all the plate magnets be energized and all the disks, therefore, turned to the limit of their travel, there will be two rows of holes lined up, each row extending entirely through the set of disks. Furthermore, one row of holes will be on the left side of the index lever and the other row will be on the right. Hence, if a pin be thrust from the back of the disks through each row of holes, so that the ends of the pins extend beyond the face of the outside disk, the index lever, rotator shaft, and typewheel can turn only until the index

THE MONARCH SYSTEM OF PRINTING TELEGRAPHY

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The construction of the disks
on the printer in Fig. 38.

lever strikes one of the pins. In case the left rotator magnet be energized, the index lever strikes the pin to the left. Likewise, in case the right rotator magnet be energized, the index lever strikes the pin to the right.

In the same way, if all four disks are in their normal position, that is, if none of the plate solenoids are energized, there are again two rows of holes through all four disks. As before, one row lies to the left of the index lever and the other to the right. These two rows are different, however, from the rows in the first case. Hence, the rotation of the index lever, rotator shaft, and typewheel is again limited in either direction, but the limits are different from what they were in the first case.

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THE NORDHOFF SYSTEM OF PRINTING TELEGRAPH MI

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Likewise, if only one of the

selector plates be turned, whereas the others remain in their normal positions, a still different row of holes will be established on each side of the index lever. No difference how the disks are placed, provided each be in extreme position or the other, two paths for the stop pins through the disks are provided, one path or row being on the left side of the index lever and the other on the right.

As a result of this arrangement, we can stop the rotation of the typewheel at fifteen different points in either direction of rotation or at thirty points in all. Considering also the center position of no rotation, we obtain a total of thirty-one different positions or points which we can assign to the typewheel. It will be remembered that we were able to send thirty-one different combinations of line impulses; as we shall see later, the first four line impulses

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

selector plates be turned, whereas the others remain in their normal positions, a still different row of holes will be established on each side of the index lever. No difference how the disks are placed, provided each be in extreme position or the other, two paths for the stop pins through the disks are provided, one path or row being on the left side of the index lever and the other on the right.

As a result of this arrangement, we can stop the rotation of the typewheel at fifteen different points in either direction of rotation or at thirty points in all. Considering also the center position of no rotation, we obtain a total of thirty-one different positions or points which we can assign to the typewheel. It will be remembered that we were able to send thirty-one different combinations of line impulses; as we shall see later, the first four line impulses

determine the positions of the selector plates, whereas the the fifth pulse determines the direction of rotation of the typewheel. We see, therefore, the purpose and action of the selector disks. Furthermore, by the use of the shift movement, the thirty-one type-wheel positions are increased to sixty-two, just as the total number of characters available for transmission was increased to sixty-two. In the Morkrum system, not all of the sixty-two possible disk combinations are utilized.

THE DRUM. The next question is how the interference or stop pins pass through the disks, are mounted, and operated. There are, in all, twenty-four of the pins, all supported on a steel frame called the drum; the frame is called the drum because of its general shape. The drum and pins are

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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shown in Figs. 38 and 39. The drum consists of two circular end-plates, P_1 and P_2, connected by supporting rods and space sleeves as shown in the figures. Each plate possesses two projections at diametrically opposite points; the projections are bored to receive the two horizontal supporting rods. The end plates are kept apart by sleeves which fit over the supporting rods. These sleeves also constitute bearings, so that the entire drum can slide back and forth on the rods. The two plates, P_1 and P_2, are similarly bored with guide holes for the interferance pins. The pins extend from one plate to the other, and project both at the front and back of the drum. On each pin is mounted a small collar, and between this collar and the left-hand plate is placed an open coil compression spring, #35-14.

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

shown in Figs. 28 and 29. The drum consists of two circular end-plates, P_7 and P_8, connected by supporting rods and space sleeves as shown in the figures. Each plate possesses two projections at diametrically opposite points; the projections are bored to receive the two horizontal supporting rods. The end plates are kept apart by sleeves which fit over the supporting rods. These sleeves also constitute bearings, so that the entire drum can slide back and forth on the rods. The two plates, P_7 and P_8, are similarly bored with grade holes for the interference pins. The pins extend from one plate to the other, and project both at the front and back of the drum. On each pin is mounted a small collar, and between this collar and the left-hand plate is placed an open coil compression spring, #28-14.

If the drum be thrust toward toward the right, the projecting pins strike the pile of selector plates. Two of the pins will be in line with holes in the plates, and will pass through the complete set of plates, as was described before. The other pins, which are not in line with the holes, cannot pass through the series of plates; hence, they strike one plate and stop. The spring mounting of the pins allows the frame to travel on to its extreme right-hand position, in which position, the two pins will extend through all four disks and into the path of the index lever.

In Fig. 38 we see also the means for thrusting the drum toward the right. Beneath the drum is a magnet called the drum magnet, which is attached to the right main bearing. A view of the drum magnet alone is presented in Fig. 43. The magnet consists of

THE MORKUM SYSTEM OF PRINTING TELEGRAPHY

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In Fig. 28 we see also the means for thrusting the drum toward the right. Beneath the drum is a magnet called the drum magnet, which is attached to the right main bearing. A view of the drum magnet alone is presented in Fig. 42. The magnet consists of

two solenoids, each fitted with a plunger core. The two cores are attched to a yoke, from the center of which extends a rod, R. This rod joins a connecting rod; the lower end of the connecting rod is mounted in a stationary pivot, whereas the upper end is forked and engages a grooved collar on the face of the drum.

When the drum magnet is energized, it draws in its plungers, and, through the linkages just described, forces the drum to the right. When the magnet is de-energized, all parts return to their starting positions under the action of the springs on the stop pins.

ROTATOR LOCK. Reference was made during the description of the rotator transmission to a lock on the rotator shaft. This is a device which holds the rotator shaft stationary while the selector mechanism is

THE MONERUM SYSTEM OF PRINTING TELEGRAPHY

two solenoids, each fitted with a plunger core. The two cores are attached to a yoke. From the center of which extends a rod, R. This rod joins a connecting rod; the lower end of the connecting rod is mounted in a stationary pivot, whereas the upper end is forked and engages a grooved collar on the face of the drum.

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ROTATOR LOCK. Reference was made during the description of the rotator transmission to a lock on the rotator shaft. This is a device which holds the rotator shaft stationary while the selector mechanism is

being set; the lock is released by the drum as it moves toward the right.

The lock on the rotator shaft is shown in Fig. 37. It consists of a semi-circular cam, M, mounted on the rotator shaft, with the flat side of the cam turned upwards. Above the cam are the two bell cranks, N N, pivoted at their elbows to the right main bracket. The lower ends of the cranks rest on the two sides of the cam, as is indicated, so that the cam and rotator shaft cannot turn. The two lower ends of the cranks are joined by a tension spring, so that they are held on the cam. The upper halves of the cranks are bent at right angles so as to lie end-to-end. Above the meeting point of the two arms is the end of a third bell crank, O. This crank is pivoted at its elbow to a lug on the inner face of the main bearing. One

being set; the lock is released by the drum as it moves toward the right.

The lock on the rotator shaft is shown in Fig. 87. It consists of a semi-circular cam, M, mounted on the rotator shaft, with the flat side of the cam turned upwards. Above the cam are the two bell cranks, N N, pivoted at their elbows to the right main bracket. The lower ends of the cranks rest on the two sides of the cam, as is indicated, so that the cam and rotator shaft cannot turn. The two lower ends of the cranks are joined by a tension spring, so that they are held on the cam. The upper halves of the cranks are bent at right angles so as to lie end-to-end. Above the meeting point of the two arms is the end of a third bell crank, O. This crank is pivoted at its elbow to a lug on the inner face of the main bearing. One

end of the crank extends through a slot in the bearing, so that it lies above the two cranks, N N, whereas the other end is bent upward. An arm,called the plunger ram, is mounted on the drum in line with the vertical arm, O.

When the drum assumes its right-hand position, the plunger ram of the drum strikes the crank, O, and moves its upper end toward the right. The horizontal end of the crank is thereby depressed, and, in moving down, strikes the ends of the cranks, N N. The bottom ends of the cranks are spread out so that they clear the locking cam, M. The rotator shaft is now free to turn. When the drum goes back to its original position, after the printing of a letter, the crank, O, is released, and all parts return to their normal positions.

THE MONARCH SYSTEM OF PRINTING TELEGRAPH

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THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

We will now take up the two remaining movements of the typewheel, viz., the movements of spacing and backing.

THE SPACER AND BACKER. The spacer is that mechanism by which the carriage and typewheel are moved side-ways after the printing of a letter, so that the next letter will be printed beside the first one. The backing movement is the carriage return. That is, it is the movement by which the carriage, after reaching the end of a printed line, is returned to its starting position at the beginning of a line. The spacer is operated automatically by the printer between letters, and is also operated between words when a space signal is received over the line. The backer is operated only when a carriage return signal is received.

The spacer and backer mechan-

THE MORRUM SYSTEM OF PRINTING TELEGRAPHY

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The spacer and backer mechan-

ism is shown is Fig. 44(a, b, c, d, and e). Fig. 44(a) is a face view of the left end of the mechanism: that part located on the left main bracket; (b) is a front or edge view of the same portion; (c) is a top view of the entire mechanism; (d) and (e) are face views of that part of the device located on the right main bracket.

As is indicated in the figures, a small chain is attched to the carriage, which chain runs to the left end of the printer, over a pulley on the left main bearing, and winds onto a drum marked "spring barrel #41-3". This drum contains a flat spiral spring, which is wound so that it tends to keep the chain wound-up on the barrel. Fig. 44(a) shows an end view of the barrel, and indicates the method of regulating the spring tension.

THE MOMENTUM SYSTEM OF MAINTAINING PERMANENCY

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ridge, which runs to the left end of

vres, a small chain is attached to the cer-

of that part of the device located on the right main bracket.

As is indicated in the figure, the entire mechanism; (d) and (e) are face views the same portion; (c) is a top view of the main bracket; (b) is a front or edge view of the mechanism: that part located on the left

Fig. 44(a) is a face view of the left end of

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The action of the spacer mechanism is to draw the carriage toward the right, by steps, against the action of the backer spring. The backer mechanism proper is merely a means for releasing the spacer, so that the carriage is free to travel to its extreme left position under the action of the backer spring. We will first describe the spacer mechanism.

The spacer is located at the right end of the printer, near the back. Referring to Fig. 44(c), we see that a second chain is attched to the carriage, runs to the right end of the printer, and there winds onto a second drum called the space drum.

The space drum consists of a barrel, at each end of which is a ratchet; the two ratchets are indentical in construc-

NEW MOVEMENT SYSTEM OF PRINTING TELEGRAPHY

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The space drum consists of
a barrel, at each end of which is a ratchet;
the two ratchets are independent in construc-

tion and mounting. The drum is supported from the space magnet bracket by a stud. The drum is turned, and the chain wound up, by the action of a pawl which engages the outside ratchet; the second pawl, which engages the second ratchet, is merely a check pawl. The two pawls are kept in contact with the ratchets by two springs as shown.

The outer pawl is mounted on a lever called the space lever. The space lever is pivoted, near its middle point, to a stud, wich, in turn, is mounted on the magnet bracket. A spring, called the space spring, keeps the left end of the spacer lever and pawl in the upper position. At its right end, the lever is connected, through an adjustable link, to the yoke of the space magnet.

The space magnets consist of two solenoids with plunger cores. The solen-

THE MORSE SYSTEM OF PRINTING TELEGRAPHY

two solenoids with plunger cores. The solenoid cores are connected by a stud. The drum is supported from the space magnet bracket by a stud. The drum is turned, and the chain wound up, by the action of a pawl which engages the outside ratchet; the second pawl, which engages the second ratchet, is merely a check pawl. The two pawls are kept in contact with the ratchets by two springs as shown.

The outer pawl is mounted on a lever called the space lever. The space lever is pivoted, near its middle point, to a stud, which, in turn, is mounted on the magnet bracket. A spring, called the space spring, keeps the left end of the spacer lever and pawl in the upper position. At its right end, the lever is connected, through an adjustable link, to the yoke of the space magnet.

The space magnets consist of

oids are fixed to the magnet bracket as indicated. The lower end of the plunger core of each solenoid is attached to the space yoke.

As for the action of the spacer, during the printing of a letter, the space magnet is energized; it draws up its plungers, the space yoke, and the right end of the space lever. This movement of the space lever draws its right end downward, and with it, the pawl; this movement is against the action of the space spring. The pawl engages one of the ratchet teeth. The check pawl has, in the meantime, kept the space drum from turning backward. When the printing of the letter is completed, the space magnet is de-energized. It therefore releases the plungers, yoke, and space lever, and the space spring raises the left end of the space lever and the pawl. This movement of the space pawl turns the ratchet and therefore

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the space pawl turns the ratchet and therefore

winds-up the carriage chain one more step. The device is so adjusted that the carriage is moved the proper distance for the spacing of the letters.

We see, therefore, that by this device, the spacing of the carriage is accomplished, and that furthermore, the spacing movement does not occur until after the printing of a letter; the operation of printing and spacing, therefore, occur at distinctly different times, as is desired.

The backing mechanism, as was stated before, is a release for the space drum, so that when the backing action takes place, the carriage travels to its left position under the action of the backing spring. The mechanism comprises a tripping lever, which draws the space and check pawls away from their ratchets, a means of operating the tripping lever, and the backing drum.

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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The tripping arrangement is shown in Fig. 44(d and e). The tripping lever is a small bell crank, pivoted at its elbow to the space lever stud, A. One end of the crank extends upward and carries a cross-rod; the cross-rod extends across the front of both pawls. The other arm of the crank terminates under the plunger rod of the backing magnet. This magnet is a single solenoid with a plunger core, to which is attached the plunger rod.

As for the action of the backer, when the backing magnet is energized, it draws its plunger and plunger rod downward; the plunger rod pushes down the end of the tripping crank, which movement draws the upper end to the right. By reason of the cross-rod at the upper end of the arm, the two pawls are also drawn to the right and away from the

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

The tripping arrangement is shown in Fig. 44(a and b). The tripping lever or is a small bell crank, pivoted at its elbow to the space lever stud, A. One end of the crank extends upward and carries a cross-rod; the cross-rod extends across the front of both pawls. The other arm of the crank terminates under the plunger rod of the backing magnet. This magnet is a simple solenoid with a plunger core, to which is attached the plunger rod.

As for the action of the backer, when the backing magnet is energized, it draws its plunger and plunger rod downward; the plunger rod pushes down the end of the tripping crank, which movement draws the upper end to the right. By reason of the cross-rod at the upper end of the arm, the two pawls are also drawn to the right and away from the

ratchets, as is shown in Fig. 44(e). The space drum is therefore released, and the carriage is drawn back to its starting position.

A locking device is added to the backer, which device locks the backer in its operative position of Fig. 44(e). This device is necessary in order that, in case the backer magnet is de-energized before the carriage has reached the left end of its travel, the space pawls will be held away from their ratchets until the carriage does reach the end of its travel. At the end of the backing movement, the carriage releases the lock.

The details of the device are shown in Fig, 44(c and d). In (c) we see a small rod, called the backing rod, extending from the left main bearing to the right main bearing; the rod is supported loosely, so that it is free to turn or to slide endways. Near its right end, the rod carries a

THE MOSCHUM MACHINE OF PRINTING INDUSTRY

waves. Near its right end, the rod carries a so that it is free to turn or to slide end-wise in bearing; the rod is supported loosely. ing from the left main bearing to the right a small rod, called the braking rod, extend- are shown in Fig. 44(c and d). In (c) we see

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A locking device is added to is drawn back to its starting position. item is therefore released, and the carriage ratchets, as is shown in Fig. 44(e). The space

small collar, called the backing collar; near the left end, the rod carries a somewhat similar collar, and between the latter collar and the left main bearing is placed an open-coil compression spring. The spring tends to keep the rod in its extreme right position.

Referring to (d) of Fig. 44, we see an end view of the backing rod and collar. It will be further noted that the plunger of the backing magnet extends above the top of that magnet, and is attached to one end of a lever called the backing lock lever. This lever is pivoted at its middle point to the magnet bracket; the other end of the lever extends to the left and terminates beside the backing rod collar.

Suppose now, that the end of a printed line has been reached by the printer. The carriage is in its extreme right po-

small collar, called the backing collar; near the left end, the rod carries a somewhat similar collar, and between the latter collar and the left main bearing is placed an opencoil compression spring. The spring tends to keep the rod in its extreme right position.

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Suppose now, that the end of a printed line has been reached by the printer. The carriage is in its extreme right po-

sition. The backing magnet is energized for an instant; it draws its plunger downward, and thereby raises the left end of the backing lock lever. Under the action of the spring on the backing rod, the backing rod and collar move short distance to the right, so that the collar is under the backing lock lever. (See Fig. 44-e). Therefore, even though the backing magnet be de-energized, its plunger is held up by the backing lock lever. The carriage travels to its left-hand position; as it reaches this position, it strikes the left-hand collar of the backing rod and moves the rod a short distance toward the left. This movement of the backing rod withdraws its collar from beneath the backing lock lever, so that the lever drops to its normal position of Fig. 44(d). When the lever is in this position, the space pawls engage their

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

ation. The locking magnet is energized for an instant; it draws its plunger downward, and thereby raises the left end of the locking lock lever. Under the action of the spring on the locking rod, the locking rod and collar move short distance to the right, so that the collar is under the locking lock lever. (See Fig. 44-e). Therefore, even though the locking magnet be de-energized, its plunger is held up by the locking lock lever. The carriage travels to its left-hand position; as it reaches this position, it strikes the left-hand collar of the locking rod and moves the rod a short distance toward the left. This movement of the locking rod withdraws its collar from beneath the locking lock lever, so that the lever drops to its normal position of Fig. 44(d). When the lever is in this position, the spare pawls engage their

ratchets; they have not engaged, however, until the carriage has reached its starting position.

An additional attachment is to be found on the space drum. This attachment is a stop pawl whose purpose is to prevent the spinning of the space drum after the backing movement is completed. While the carriage is travelling back to its starting position, the space drum is turning backward rapidly; it has been found more desirable to stop the drum at the end of the backing movement by a special stop pawl, rather than to allow the check and space pawls to drop onto the ratchets while they are revolving.

The lower part of the stop pawl may be seen in Fig. 44(d and e). This pawl is pivoted to a bearing on the base-plate.

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The lower part of the stop pawl may be seen in Fig. 44(d and e). This pawl is pivoted to a bearing on the base-plate

The upper part of the pawl splits into two fingers; one finger bears on the face of the drum, whereas the other extends along the back of the rear ratchet. The face of the ratchet carries a small stud or pin. When the carriage is in its starting position, the stud rests on the top of the rear finger of the pawl; as the carriage is drawn toward the right by the winding of the chain onto the space drum, that finger of the pawl which rests on the face of the drum rises onto the chain wound on the drum, and rides on the top of the chain instead of on the face of the drum. Both pawls are thereby lifted away from their former positions, so that the back finger clears the path of the stud on the ratchet. As the drum unwinds, during the backing movement, the pawl assumes its former position, so that just as the carriage reaches its starting position, the in-

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

The upper part of the pawl splits into two fingers; one finger bears on the face of the drum, whereas the other extends along the back of the rear retchet. The face of the retchet carries a small stud or pin. When the carriage is in its starting position, the stud rests on the top of the rear finger of the pawl; as the carriage is drawn onto the space drum, that finger of the pawl which rests on the face of the drum rises onto the chain wound on the drum, and rides on the top of the chain instead of on the face of the drum. Both pawls are thereby lifted away from their former positions, so that the back finger clears the path of the stud on the retchet. As the drum unwinds, during the printing movement, the pawl assumes the former position. so that just as the carriage reaches its starting position, the in-

terference stud strikes the stop pawl. The space drum therefore stops, and the space palws drop onto the ratchets.

We will now take up a study of the platen, and of the lining mechanism , which is closely associated with the platen.

THE PLATEN AND LINER. The complete platen, with the lining mechanism, is shown in Fig. 45. The platen consists of the roller and auxiliary attachments for holding the message blank or other paper. The lining mechanism is the arrangement by which the roller is turned slightly at the end of each line, so that the message blank presents a new surface for the next printed line. Fig. 45 is a catalogue drawing of the platen; only the main parts will be discussed here.

The frame of the platen consists of the cover of the printer, casting #1, together with two end plates, marked re-

THE MORRUM SYSTEM OF PRINTING TELEGRAPHY

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THE PLATEN AND LINER. The complete platen, with the linking mechanism, is shown in Fig. 45. The platen consists of the roller and auxiliary attachments for holding the message blank or other paper. The linking mechanism is the arrangement by which the roller is turned slightly at the end of each line, so that the message blank presents a new surface for the next printed line. Fig. 45 is a catalogue drawing of the platen; only the main parts will be discussed here.

The frame of the platen consists of the cover of the printer, casting 41, together with two end plates, marked re-

spectively, casting #2 and casting #3. The screws at the four corners of the cover plate screw into the four corners of the main frame of the printer; the end castings are screwed onto the cover plate.

The platen, in its restricted sense, is a rubber roller, similar to that of a typewriter. It is mounted on the platen shaft, #5-1, which is supported by the end casting in bearings. At either end of the shaft is a hard-rubber thumb-wheel, by which the platen may be turned. There are a number of auxiliary attachments on the platen, the most important of which attachments is the one for holding the paper against the roller.

This latter device consists of the two feed rolls, #14 and #15 respectively, and their mountings. These two rolls bear against the roller, and hold the paper snugly against the roller. The two rolls may

respectively, casting #2 and casting #3. The screws at the four corners of the cover plate screw into the four corners of the main frame of the printer; the end castings are screwed onto the cover plate.

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be drawn away from the platen by the arrangement shown in Fig. 45(a). The rolls are mounted on a spring rod, as shown, which is screwed at its right end to the end casting. The front end of the spring lays across a rod known as the release rod, which extends from one end casting to the other, and is fitted into bearings at either end. At the point where the spring rod lays across the release rod, the latter is cut down to semi-circular form; the spring rod lays across the flat face thereby secured. The release rod carries a small lever, marked #18 Rolls handle, by which it may be turned. The mechanism so far described is duplicated at the left end of the platen.

In the operation of the attachment, the feed rolls normally lie close against the platen, as in (a). However, if the rolls handle and release rod be turned,

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In the operation of the attachment, the feed rolls normally lie close against the platen, as in (a). However, if the rolls handle and release rod be turned,

the spring rod is pushed downward until it finally lays across the round side of the release rod. This movement of the spring rod pull the feed rolls away from the platen. When the rolls handle is pushed back to its original position, all parts return to their usual positions.

The purpose of the device is to release the message blank so that it may be withdrawn from the platen or its position adjusted.

The lining mechanism can better be understood from the end view of the platen. Referring to this view, we see the ratchet mounted on the platen shaft. The ratchet and platen are ordinarily held in position by the detent roll as shown. At the left of the ratchet is a lever, L, which carries two pawls: the lining pawl and the stop pawl. The lever and pawls are connected with the

THE MORKRUM ALARM OR PRINTING TELEGRAPH

The lever and pawls are connected with the two pawls: the lifting pawl and the stop pawl. The lever, L, which carries one of the ratchet is a lever, L, which carries tion by the detent roll as shown. At the left et and platen are ordinarily held in posi- ratchet mounted on the platen shaft. The ratch- platen. Referring to this view, we see the ter be understood from the end view of the

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to release the message blank so that it may be withdrawn from the platen or its position adjusted.

The purpose of the device is original position, all parts return to their usual positions.

When the rolls handle is pushed back to its rod pull the feed rolls away from the platen. release rod. This movement of the spring finally lays across the round side of the the spring rod is pushed downward until it

lining magnet as shown. In the operation of the liner, the lining magnet is first energized. The magnet moves the lever, L, toward the right, and, through the agency of the lining pawl, turns the ratchet and feed roll toward the left; this turning is the equivalent of either one or two lines on the message blank. The stop pawl serves to stop the turning. The position of the stop pawl may be changed by means of the lever, A. When the stop pawl is in one position, two lines on the message blank are turned up at every stroke of the lining magnet; when the pawl is in the other position, one only is turned up at a time.

We have now completed the discussion of the principal mechanical features of the Morkrum printer, and will next take up a study of the electrical circuits and equipment by which the mechanical devices

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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THE PRINTER CIRCUITS. In Fig. 46 are given the complete circuits of the Morkrum printer. As the general circuits are too complicated for purposes of explanation, the constituent circuits will be separated from the rest and discussed one at a time. In order that the reader may thoroughly understand the fundamental plan of the control, the main circuit will be developed by stages, as was done with the distribution system in the introduction. In fact, we will begin with the receiving station of Fig. 6, and develope the printer circuits from that scheme.

In Fig, 47, we have the receiving station of Fig. 6, except that the local relays, P-1, P-2, P-3, P-4, and P-5, are connected so as to lock themselves in the energized or closed position. That is,

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the front points are connected to one side of the battery, and the armatures are connected to their respective operating coils, as shown. If one relay is momentarily energized, as it will be by a current pulse, it draws up its armature against its front contact; with this contact closed, the relay remains energized, even after the current pulse has ceased. This locking circuit is connected to the battery through a switch called the main break. A momentary opening of this switch cuts off the locking current from the relays for a time sufficient for them to return to their normal condition.

As a possible use for the system, we could establish a printing system with these five relays. The first four relays might act as operating solenoids for the selector plates, and the fifth relay might determine the direction of rotation of the typewheel. Furthermore, by fitting the solenoids with relay contacts other than

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their locking contacts, we arrange the operating circuits, that is, the circuits of the rotator, striker, shift, and other magnets. A control circuit could be developed, and, in fact, some such plan is followed in the Morkrum printer.

The cycle of operations for such a machine would be as follows: The receiver brush passes over the receiver buttons, 1, 2, 3, 4, and 5, and the five plate relays are operated or else remain inoperative, depending upon the nature of the separate impulses. The plate relays set the selector plates, and at the same time, set up the circuits of the operating mechanisms. Hence, after the fifth pulse, the typewheel rotates, strikes, and spaces. The final printer movement is to open the main break for an instant, so that the plate relays return to their normal positions. By this time, the brush has

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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again reached the first contact button, and the same cycle of operation occurs for the next letter. In this way, the printer would perform its functions.

The great fault of such a system is this: All the movements of the type-wheel must occur during the interval of time required by the brush arm in passing from contact button #5 to button #1. If The transmission of messages is performed at any practical speed, this interval of time is too short for the typewheel to complete its movements. We therefore modify the system of Fig. 47 somewhat, so that one letter is being printed while the next one is being received over the line.

THE ACTUAL SELECTOR CIRCUITS. The new scheme, which is the one used in the Morkrum system, is presented in Fig. 50. In this plan, the plate relays are not connected

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY.

again received the first contact button, and the same cycle of operation occurs for the next letter. In this way, the printer would perform its functions.

The great fault of such a system is this: All the movements of the type-wheel must occur during the interval of time required by the break arm in passing from contact button #5 to button #1. If the transmission of messages is performed at any practical speed, this interval of time is too short for the typewheel to complete its movements. We therefore modify the system of Fig. 47 somewhat, so that one letter is being printed while the next one is being received over the line.

THE ACTUAL SENDING CIRCUITS.

The new scheme, which is the one used in the Morkrum system, is presented in Fig. 50. In this plan, the plate relays are not connected

to the receiver contact buttons. Instead, a second series of relays, called lock relays, are connected to the contact buttons, and the plate relays are controlled from this second set. It seems advisable, for purposes of explanation, to build up the plan of the control circuits between the lock and plate relays.

THE LOCK RELAY CIRCUITS.

The connections of the lock relays and transmitter disk are shown schematically in Fig. 48. Note that the lock relays of Fig. 48 have taken the places of the local relays in the distributing system of Fig. 6. As is indicated, the lock relays lock themselves in the operative position, just as the plate relays do in the preceeding scheme. The locking current in this case, however, comes through the back contacts of a sixth relay, similar

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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THE LOCK RELAY CIRCUITS.

The connections of the lock relays and transmitter disk are shown schematically in Fig. 48. Note that the lock relays of Fig. 48 have taken the places of the local relays in the distributing system of Fig. 8. As is indicated, the lock relays lock themselves in the operative position, just as the plate relays do in the preceeding scheme. The locking current in this case, however, comes through the back contacts of a sixth relay, similar

to the others, and called the selector break. The circuits are so arranged that when the selector break coils are de-energized, and the armature lies against the back point, the locking circuit is closed to the battery; when the coils are energized, the armature is drawn away from the back point, and the locking circuit is separated from the battery. Hence, when the selector break opens, it releases any of the lock relays which have been locked in the operative position.

The control of the selector break is through a button on the receiver disk. This button, called the restoring button, is double size, and corresponds to both the positive and negative synchronizing buttons of the transmitting disk. It will be remembered that once every revolution of the transmitter brush arm, a marking impulse is sent out from the negative synchronizing but-

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to; hence, the selector break is energized and operates once every revolution of the brush arms. Furthermore, the opening of the selector break occurs between successive letters, so that the lock relays are "restored" after the reception of each impulse combination.

The lock relay, L-5, does not lock itself in position with current from the selector break; we will presently see the reason for this fact.

It might be well to state here a condition which is general in all the Morkrum circuits, viz., one side of the battery is permanently grounded, and one side of every solenoid or relay is permanently grounded. Therefore, only one additional path need be established between the battery and the magnet in question.

THE MORSE-KEY OR PRINTING TELEGRAPH

to; hence, the selector break is energized and operates once every revolution of the break arms. Furthermore, the opening of the selector break occurs between successive letters, so that the lock relays are "restored" after the reception of each impulse combination.

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THE LOCK AND PLATE RELAY CIRCUITS. The connection from lock to plate relays is shown in Fig. 49. Here we see that the five plate relays are connected in parallel with their respective lock relays. The two sets of instruments are connected in parallel through four back contacts of a relay known as the divide relay. Plate and lock relays #5 form an exception to the general arrangement: they are connected directly in parallel. The plate relays lock themselves in the operated position by current through the main break, just as before, although the locking circuit is not shown.

By this arrangement, if the contacts of the divide relay are closed, as they are when the divide relay is not energized, the plate and lock relays are in parallel. The plate relays will, therefore, follow any movements of the lock relays. Since

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the lock relays are governed by the incoming line impulses, the plate relays also register the character of the impulses.

If the contacts of the divide be opened, as they will be when the instrument is energized, the two banks of relays are separated. The first four lock relays act just as before, but the plate relays are not affected by the line impulses. Since the locking circuits of the two sets of relays are independent, the plate relays remain in the position in which they were at the opening of the divide contacts; then, when the main break opens, locking current is cut off from the plate relays, and they resume their inoperative position.

As for the operating circuits of the divide relay, the relay coils are connected to one tongue of the relay. The back point, corresponding to this tongue, is con-

THE MORRUM SYSTEM OF PRINTING TELEGRAPHY

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As for the operating circuits of the divide relay, the relay coils are connected to one tongue of the relay. The back point, corresponding to this tongue, is con-

nected to the restoring button of the receiver disk. When the relay is in its usual position, there is a current path from the restoring button, through the brush and brush arm, through the divide relay contact to the operating coils, and thence to ground. Hence, when a marking pulse occurs at the restoring button,as it does once every revolution of the brush arm, the divide relay is energized. It therefore draws its armature against the front contact, and thereby cuts itself off from the receiver disk. As we shall see presently, the front contact is connected to the battery through the main break; hence, the divide relay is locked in its operative position until the opening of the main break. At the same time that the divide relay has changed its own circuit, it has separated the lock and plate relays.

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When we go a step further, and apply the scheme just described to the scheme of Fig. 47, the result is the circuit presented in Fig. 50. As was said before, Fig. 50 shows the lock and plate relay circuits actually used in the Morkum printer.

FINAL SELECTOR CIRCUITS. In Fig. 50, the lock relays are connected to the receiver disk just as in Fig. 48, and they receive their locking current through the back contact of the selector break. The first four relays are connected in parallel with their respective plate relays through the back contacts of the divide, just as before. The fifth relays are connected directly in parallel. The five plate relays and the fifth lock relay receive locking current through the main break. The selector break and divide relays are connected to the restoring button of the receiver disk. The di-

storing button of the receiver disk. The divide relays are connected to the main break. The selector break through the fifth lock relay receive locking current the fifth relay are connected in parallel. The five plate relays and fore. The fifth relays are connected direct-ly in parallel, just as be-the back contacts of the divide, with their respective plate relays through first four relays are connected in parallel the back contact of the selector break. The they receive their locking current through the receiver disk just as in Fig. 49, and Fig. 50, the lock relays are connected to

MIXT CONNECTOR CIRCUITS. In

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vide relay receives locking current through the main break. We see, therefore, that although the arrangement of the figure has been changed somewhat from that given in Figs. 48 and 49, the electrical connections are just the same. There are, however, two additional devices in Fig. 50.

The first of the new devices is the drum magnet and drum switch. The drum magnet is connected to the battery through one of the front contacts of the divide, so that the magnet is energized while the divide relay is closed. Furthermore, the drum magnet carries a switch called the drum switch; this switch closes when the drum magnet is energized. The purpose of the switch is to connect the battery into the distribution circuit, as that circuit is called which serves to operate the rotator magnets or other printer functions. That is, the drum switch con-

THE NORMAL SYSTEM OF SIGNALING TELEGRAPHY

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nects the battery to the semi-automatic functions of the printer.

The other additional feature is the signal lamp. As is indicated, the lamp is controlled by an additional lock relay, identical with the other lock relays. When a marking pulse is received by the lamp button, the lamp lights, whereas if a spacing pulse is received, the lamp stays dark. The action is apparent from the diagram.

We will now trace through the cycle of operations with the system of Fig. 50, remembering that the idea of the scheme is to allow one letter to be printed while the next letter is being received over the line. Suppose, for example, that the signal ++−−−(the letter A) is received.

The action of the lock relays is for instruments #3, 4, and 5 to operate, since the relays respond only to marking

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

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pulses, and #1 and 2 to remain inoperative. Lock relays #3 and 4 lock themselves in the operative position with current from the selector break. The five plate relays duplicate the settings of the lock relays, and #3, 4, and 5 lock themselves in position with current from the main break. L-5 is also locked by current from the main break. This action takes place while the receiver brush is passing over the five contact buttons, #1, 2, 3, 4, and 5.

When the brush reaches the restoring button, the selector break and divide relays are operated. The divide relay separates the first four plate relays from the lock relays and locks itself in position. Hence, the separation of the lock and plate relays is maintained after the brush has left the restoring button. At the same time, the selector break cuts off locking current from

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the first four lock relays, and these relays resume the inoperative position. The fifth lock relay remains locked with the fifth plate relay. The selector break remains energized only as long as the brush is in contact with the restoring button, but this time is long enough to allow the relays to unlock and assume their inoperative positions.

As a result of these movements, we have lock relays #1, 2, 3, and 4 de-energized, and #5 still energized and locked in position. Plate relays #1 and 2 are inoperative, whereas #3, 4, and 5 are energized and are locked in position. The selector plates are therefore set, and ready for the printing operations to begin.

Besides separating the lock and plate relays, the divide relay has, at this time, completed the circuit of the drum magnet. This magnet draws in its armature,

THE MORGRUM SYSTEM OF SWITCHING TELEGRAPHY

the first four lock relays, and these relays resume the inoperative position. The fifth lock relay remains locked with the fifth plate relay. The selector brush remains energized only as long as the brush is in contact with the restoring button, but this time is long enough to allow the relays to unlock and assume their inoperative positions.

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Besides operating the lock and plate relays, the divide relay has, at this time, completed the circuit of the drum magnet. This magnet draws in its armature,

and thereby sets the interference pins of the selector. The drum magnet also closes the drum switch. This switch connects the battery to the printing functions, so that the printing action now takes place.

In the meantime, the lock relays have been receiving the first two or three line impulses of the next letter, and have stored these impulses by the locking of the lock relays.

The final movement of the printer, during the printing of a letter, momentarily opens the main break. This momentary opening cuts off locking current from the divide and plate relays, together with L-5, for a sufficient interval of time for these instruments to return to their normal positions. Note that the unlocking of the divide relay restores the drum magnet and

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drum switch to their inoperative positions. The operation of returning the divide and plate relays, with the other printer parts, to their normal positions is known as "clearing" the printer.

As soon as the divide relay assumes its normal position, the plate and lock relays are again connected in parallel. Hence, the plate relays immediately assume the positions of their respective lock relays. For example, if the first three impulses of the next letter have been received by the lock relays at the time the printer is cleared, and these three impulses are + − +, then P-1 will remain inoperative like L-1; P-2 will operate, just as 1-2 has done; and P-3 will, like L-3, remain inoperative. The remainder of the series will be registered by both sets of relays, just as before. The printing of the second character then proceeds,

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The reason for not connecting the lock and plate relays #5 through the divide is now apparent: The plate relays are always released before the fifth pulse of the next character is received, so that there is no need of separating the relays.

By this arrangement, then, we can print one letter while the next one is being received over the line. The printer in this form responds satisfactorily to the rapid transmission of signals. As was stated before, this arrangement just described is the one used in the Morkrum printer.

Before we take up a study of the functional circuits, that is, the circuits of the rotator, striker, shift, and other operating magnets, it seems advisable to consider the construction of the electrical equipment of the selector circuits just

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described.

INSTRUMENTS. The lock, divide, and selector break relays are standard "U" relays, such as are used for the relay pole changers; the divide relay, however, is fitted with three tongues on one unit and two on the other. The two units are connected in series, so that they act as a single relay.

The lock, selector break, and divide relays are not included in the printer itself, but are mounted separately, as is shown in Fig. 51. The instruments are attached in a row to an iron base plate, the combination being known as the "A bank".

The plate relays are quite similar to the U relays, except that they are fitted with plunger cores. They therefore act as operating solenoids as well as relays.

The other relays of the print-

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The arrangement of the relays in the printer is shown in Fig. 53. There is a back view of the printer shown in this figure. All the relays with the exception of the shift and main break relays are mounted on the relay bracket, previously described. The latter two relays are mounted on the shift relay bracket.

The drum switch is shown in Fig, 43. As indicated, it is a single contact switch at the left end of the drum magnet. The switch lever is attached to the yoke of the drum magnet, so that when the magnet is energized, and the yoke is drawn toward the

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right, the switch is closed. Ordinarily, the yoke is in its extreme left position (as in the figure), so that the switch is open.

The main break is shown in place on the machine in Fig. 52. It is located at the left end of the printer, and is supported from the frame. The break consists of two heavy contact points, one of which is fixed, and the other of which is mounted on the end of a lever. The two points are normally held together by a spring. The lever is pivoted to the supporting bracket. The back end of the lever carries a buffer, which lies in the path of an arm attached to the striker shaft. Therefore, when the striker shaft turns, it opens the main break.

An electrical means is also provided for opening the main break. A solenoid with a plunger core is located below the

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An electrical means is also
or shaft turns, it opens the main break.
the striker shaft. Therefore, when the strik-
which lies in the path of an arm attached to
The back end of the lever carries a buffer.
lever is pivoted to the supporting bracket.
are normally held together by a spring. The
mounted on the end of a lever. The two points
which is fixed, and the other of which is
plate of two heavy contact points, one of
is supported from the frame. The break con-
cated at the left end of the printer, and
place on the machine in Fig. 82. It is lo-

The main break is shown in
the figure), so that the switch is open.
yoke is in the extreme left position (as in
right, the switch is closed. Ordinarily, the

contact lever. A plunger rod extends upward from the core, the contact rod being in the path of this plunger. When the solenoid is energized, it draws up its core, the plunger, and the end of the contact lever. This movement of the lever opens the break. The plunger is ordinarily held down by the spring, as is indicated.

The electrical means of opening the break are used when a line signal is received which requires no striking action of the typewheel, for example, a carriage return signal. No striking accompanies such a signal, so that the striker shaft cannot open the main break; the electrical method must be used instead.

OPERATING CIRCUITS. The next subject in the order of treatment of the printer is the operating circuits, as distinguish-

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contact lever. A plunger rod extends upward from the core, the contact rod being in the path of this plunger. When the solenoid is energized, it draws up its core, the plunger, and the end of the contact lever. This movement of the lever opens the break. The plunger is ordinarily held down by the spring, as is indicated.

The electrical means of opening the break are used when a line signal is received which requires no printing action of the typewheel, for example, a carriage return signal. In printing accompanies such a signal, so that the printer wheel cannot open the main break; the electrical method must be used instead.

OPERATING CIRCUITS. The next subject in the order of treatment of the printer in the operating circuits, as distinguish-

ed from the selector circuits, just described. In general, it may be said that each individual function, such as that of rotation, lining, etc.,has its own permanent local circuit. This local circuitreceives power from the battery through a second circuit, known as the printer distribution circuit. This circuit should not be confused with the circuits of the distributors: the two are entirely distinct. The printer distribution circuit is not a permanent one,but instead, its character depends upon the setting of the plate relays. The distributing circuit receives current from the battery through the drum switch, so that the individual functions do not operate until this switch is closed. In the detailed description of the operating circuits which follows, the general plan of treatment will be, first, to present the

of treatment will be, first, to present the
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In the detailed description of the operat-
do not operate until this switch is closed.
drum switch, so that the individual functions
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plate relays. The distributing circuit re-
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cuit is not a permanent one,but instead, its
ly distinct. The printer distribution cir-
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circuit should not be confused with the cir-
as the printer distribution circuit. This
the battery through a second circuit, known
cuit. This local circuitreceives power from
ing, etc.,has its own permanent local cir-
nal function, such as that of rotation, lim-
In general, it may be said that each individ-
ed from the selector circuits, just described.

individual circuits of the rotator, striker, and spacer functions, i.e., those which are automatically performed during the printing of a letter; second, to explain that part of the distributing circuit which is concerned in the action of these functions; next, to describe the individual circuits of the shift, spacer and backer, rub out, and liner, i.e., those functions which require special line signals for their performance; and last, to show that part of the distributor circuit which supplies current to these latter functions.

ROTATOR CIRCUITS. The rotator circuits are shown in Fig. 54. Here, the right and left rotator magnets are connected together at the point A, which point is grounded through a relay called the print relay (not the printer relay); the purpose of the print relay will be explained presently. The two

individual circuits of the rotator, striker, and spacer functions, i.e., those which are automatically performed during the printing of a letter; second, to explain that part of the distributing circuit which is concerned in the action of these functions; next, to describe the individual circuits of the shift, spacer and breaker, rub out, and liner, i.e., those functions which require special line signals for their performance; and last, to show that part of the distributor circuit which supplies current to these latter functions.

ROTATOR CIRCUITS. The rotator circuits are shown in Fig. 54. Here, the right and left rotator magnets are connected together at the point A, which point is grounded through a relay called the print relay (not the printer relay); the purpose of the print relay will be explained presently. The two

remaining terminals of the right and left rotator magnets are connected respectively to the first front and first back point of the relay P-5. During operation, the tongue corresponding to these points is connected to the battery, this connection being established through the distributor circuit.

In the operation of the rotators, if the relay P-5 be de-energized, (as is indicated in Fig. 54) the first tongue will lie against its back contact so that the left rotator magnet will receive current. The energy is supplied to the magnets by the closing of the drum switch.

If the relay P-5 is energized, the tongue will lie against the front point; hence, the right rotator will be energized upon the closing of the drum switch, instead of the left. Hence, through the agency of

remaining terminals of the right and left rotator magnets are connected respectively to the first front and first back point of the relay P-5. During operation, the tongue corresponding to these points is connected to the battery, this connection being established through the distributor circuit.

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If the relay P-5 is energized, the tongue will lie against the front point; hence, the right rotator will be energized upon the closing of the drum switch, instead of the left. Hence, through the agency of

the relay P-5, the fifth pulse determines the direction of rotation of the typewheel. Note that the print relay is connected in the circuit in either case.

CENTER LETTER CIRCUIT. In Fig. 56 is presented the circuit utilized when the letter D is printed. This letter is so located on the typewheel that no rotation of the wheel is required in the printing of the letter. Hence, the distributing circuit diverts the current from the rotator coils, and passes it through the center letter resistance instead. From this resistance, the current path is through the print relay to ground as before. The center letter resistance is a coil of the same resistance as either rotator coil, and is used for a compensator for such a coil when absent. When the center letter line signal occurs,

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the relay 1-5, the fifth pulse determines the direction of rotation of the typewheel. Note that the print relay is connected in the circuit in either case.

CENTER LETTER CIRCUIT. In Fig. 86 is presented the circuit utilized when the letter D is printed. This letter is so located on the typewheel that no rotation of the wheel is required in the printing of the letter. Hence, the distributing circuit diverts the current from the rotator coils, and passes it through the center letter resistance inserted. From this resistance, the current path is through the print relay to ground as before. The center letter resistance is a coil of the same resistance as either rotator coil, and is used for a compensator for when a coil when absent.

When the center letter line signal occurs,

the third tongue of P-5 is connected to the battery through the distribution circuit and drum switch; the third front point is connected to the center letter circuit. The fifth pulse of the letter D is marking, so that P-5 is operated, and the battery thereby connected to the center letter circuit.

SPACER AND STRIKER CIRCUITS.

In Fig. 55 we see the spacer and striker circuits and also learn the purpose of the print relay. The spacer and striker coils are connected in series, so that they are energized simultaneously. As is indicated, the current path leads through the striker coils, through the second front contact of the print relay, through the spacer coils, first front contact of the print relay, through the main break, battery, and ground to the striker coils again. The circuit is not closed unless the main break is closed and the print relay is in the

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the third tongue of F-5 is connected to the battery through the distribution circuit and drum switch; the third front point is connected to the center letter circuit. The fifth pulse of the letter C is marking, so that F-5 is operated, and the battery thereby connected to the center letter circuit.

SPACER AND STRIKER CIRCUITS.

In Fig. 55 we see the spacer and striker circuits and also learn the purpose of the print relay. The spacer and striker coils are connected in series, so that they are energized simultaneously. As is indicated, the current path leads through the striker coils, through the second front contact of the print relay, through the spacer coils, first front contact of the print relay, through the main break, battery, and ground to the striker coils again. The circuit is not closed unless the main break is closed and the print relay is in the

energized position.

In the operation of printing, the first condition of the apparatus is this: the main break is closed, the print relay tongues on their back points, and consequently, the striker and spacer coils de-energized. Next, the print relay receives current from the distributing circuit at the same time as the rotator coils. Hence, while the rotator magnets are turning the typewheel, the print relay is drawing its armatures over to their front points, so that by the time the typewheel has been turned into the proper position, the circuit of the striker magnets has been completed and the magnets are energized. The stroke of the typewheel then occurs. The spacer magnet has, by this time, set the spacer mechanism. At the end of the typewheel stroke, the striker opens the main break, which opening clears the printer. As

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energized position.

In the operation of printing, the first condition of the apparatus is this: the main break is closed, the print relay tongues on their back points, and consequently, the striker and spacer coils de-energized. Next, the print relay receives current from the distributing circuit at the same time as the rotator coils. Hence, while the rotator magnets are turning the typewheel, the print relay is drawing its armatures over to their front points, so that by the time the typewheel has been turned into the proper position, the circuit of the striker magnets has been completed and the magnets are energized. The stroke of the typewheel then occurs. The spacer magnet has, by this time, set the spacer mechanism. At the end of the typewheel stroke, the striker opens the main break, which opening clears the printer. As

soon as the spacer magnets are de-energized, the spacing of the carriage takes place. Therefore, all parts are in their starting or inoperative positions, ready to respond to the next signal.

The purpose of the print relay was indicated in the preceding paragraph. Its purpose is to assure an interval of time between the rotating and striking movements of the typewheel. If the striker and rotator coils were connected directly in series, instead of being connected as they are, the two movements would occur simultaneously, and would, thereby, prevent the correct printing of the characters. By joining the movements through the print relay, the striking does not occur until after the rotating.

Having completed the explanation of the individual circuits used in the movements purely of a printing nature, we will now consider the distributing circuit by which these individual circuits are con-

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the spacing of the carriage takes place. There-
soon as the spacer magnets are de-energized,

nected to the battery.

THE PRINTER DISTRIBUTION CIRCUIT. The distributing circuit is shown in Fig. 57; this is not the complete circuit, but only that part of the entire circuit which is concerned the the operations just described. The circuit is made up of certain contacts on the plate relays, together with jumpers which connect these contacts. The current path through the distributing circuit depends upon the setting of these contacts. In Fig. 57, those tongues and contacts which are shown without connections are not a part of the circuit now in question. Note that there are two P-5 relays, the coils of the two being connected in series, so that they act as a single instrument. The beginning of the circuit is the second tongue of P-3, which tongue is permanently connected to the drum switch.

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

nected to the battery.

THE PRINTER DISTRIBUTION CIR-CUIT. The distributing circuit is shown in Fig. 87; this is not the complete circuit, but only that part of the entire circuit which is concerned the the operations just described. The circuit is made up of certain contacts on the plate relays, together with jumpers which connect these contacts. The current path through the distributing circuit depends upon the setting of these contacts. In Fig. 87, those tongues and contacts which are shown without connections are not a part of the circuit now in question. Note that there are two P-B relays, the coils of the two being connected in series, so that they act as a single instrument. The beginning of the circuit is the second tongue of P-B, which tongue is permanently connected to the drum switch.

Hence, when the drum switch is closed, the distributing circuit is connected to the battery.

Considering the distributing circuit from the standpoint of the rotators, we can make a table of those line impulses which will cause rotation of the typewheel. For this rotation to occur, the tongue of P-3 must be connected to the tongue of P-5. Such a table is given below; a negative or marking pulse indicates that the corresponding plate relay will be operated; a positive or spacing pulse indicates that the corresponding relay will be inoperative.

P-3	P-2	P-1	P-4	P-5
−	±	±	±	±
+	+	±	±	±
+	+	−	−	±

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

Hence, when the drum switch is closed, the distributing circuit is connected to the battery.

Considering the distributing circuit from the standpoint of the rotators, we can make a table of those line impulses which will cause rotation of the typewheel. For this rotation to occur, the tongue of P-3 must be connected to the tongue of P-5. Such a table is given below; a negative or marking pulse indicates that the corresponding plate relay will be operated; a positive or spacing pulse indicates that the corresponding relay will be inoperative.

P-3	P-2	P-1	P-4	P-5

A comparison of the table with Fig. 57 shows that any one of the combinations of signals will produce relay settings such that the tongue of P-3 is connected to the tongue of P-5. A comparison of the table with the Morkrum code shows that every printed character of the code (as distinguished from the operating signals) is included in the combinations of the table, with the exception of the center characters, D and $. No rotation of the typewheel is desired in the printing of these characters.

In the printing of the center characters, it is desired that the second tongue of P-3 be connected to the third tongue of P-5, and that P-5 be energized, so that its third tongue will lie against the front point. Tracing through Fig. 57, we find that the set-up+++---, which is that of the center letters, produces this condition. Further-

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In the printing of the semaphore characters, it is desired that the second tongue of P-5 be connected to the third tongue of P-6, and that P-5 be energized, so that the third tongue will lie against the front point. Tracing through Fig. 87, we find that the set-up ——, which is that of the center letters, produces this condition. Furthermore, typewheel is desired in the printing of these characters.

In the printing of the semaphore characters, it is desired that the second tongue of P-5 be connected to the third tongue of P-6, and that P-5 be energized, so that the third tongue will lie against the front point. Tracing through Fig. 87, we find that the set-up ——, which is that of the center letters, produces this condition. Furthermore, typewheel is desired in the printing of these characters. D and ', No rotation of the carriage is required in the printing of the characters of the table, with the exception of the semaphore characters. The code (as distinguished from the operating signals) is included in the combinations of the table, with the exception of the semaphore characters. D and '. No rotation of the typewheel is desired in the printing of these characters.

In the printing of the semaphore characters, it is desired that the second tongue of P-5 be connected to the third tongue of P-6, and that P-5 be energized, so that the third tongue will lie against the front point. Tracing through Fig. 87, we find that the set-up ——, which is that of the center letters, produces this condition. Furthermore, a comparison of the table with Fig. 87 shows that any one of the combinations of signals will produce relay settings such that the tongue of P-5 is connected to the tongue of P-6. A comparison of the table with the Morkrum code shows that every printed character of the code (as distinguished from the operating signals) is included in the combinations of the table, with the exception of the semaphore characters. D and '. No rotation of the typewheel is desired in the printing of these characters.

more, there is no connection from the distributing circuit to the rotators, so that no rotation occurs.

OPERATING CIRCUITS. Having now completed the discussion of the first class of functions, we come to the second class, viz., those which are purely operative in their character, and require special line signals. These functions are: spacing (between words), lining, shift, backing, and rub out. Before taking up the operation of these functions, however, we must consider a new feature which the printer displays when responding to such signals.

THE MAIN BREAK CONTROL. The new feature is the opening of the main break by electrical means. It will be remembered that the main break may be opened mechanically by the striker mechanism. Since the striker

THE WORKING VIEWS OF PRINTING TELEGRAPHY

more, there is no connection from the distributing circuit to the rotators, so that no rotation occurs.

OTHER KEYING CIRCUITS. Having now completed the discussion of the first class of functions, we come to the second class, viz., those which are purely operative in their character, and require special line signals. These functions are: spacing (between words), lining, shift, backing, and run out. Before taking up the operation of these functions, however, we must consider a new feature which the printer displays when responding to such signals.

THE MAIN BREAK CONTROL. The new feature is the opening of the main break by electrical means. It will be remembered that the main break may be opened mechanically by the striker mechanism. Since the striker

does not operate when one of the operating signals is received, the main break must be opened by electrical means.

The main break control circuit is shown in Fig. 58. In this diagram, the circuit of the main break magnet leads from one side of the battery, through the break itself, through the front contacts of the main break relay, through the current limiting resistance, through the main break magnet to ground, and thence to battery. When the main break magnet is energized, the main break is open; when the main break magnet is de-energized, as it normally is, the break is closed.

In the utilization of the circuit, the main break magnet and main break relay are at first not energized. The coils of the relay are connected in series with what-

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does not operate when one of the operating signals is received, the main break must be opened by electrical means.

The main break control circuit is shown in Fig. 58. In this diagram, the circuit of the main break magnet leads from one side of the battery, through the break itself, through the front contacts of the main break relay, through the current limiting resistance, through the main break magnet to ground, and thence to battery. When the main break magnet is energized, the main break is open; when the main break magnet is de-energized, as it normally is, the break is closed.

In the utilization of the circuit, the main break magnet and main break relay are at first not energized. The coils of the relay are connected in series with what-

ever printer function is being used. Then, when the current for the function appears, it not only energizes the functional magnets, but energizes the relay coils as well. The relay then picks-up, as is shown in the figure. This position of the relay completes the current path from the battery to the main break coils, and the main break opens.

The reason for using the main break relay to control the break, instead of connecting the coils of the break itself into circuit of the function, is to insure the complete operation of the function before the opening of the main break.

THE SPACING CIRCUIT. The spacing circuit is shown in Fig. 59. This is the circuit utilized when a space signal is received over the line, usually between words. The spacing is performed in exactly

THE MORKRUM SYSTEM OF PRINTING TELEGRAPHY

over printer function is being used. Then, when the current for the function appears, it not only energizes the functional magnets, but energizes the relay coils as well. The relay then picks-up, as is shown in the figure. This position of the relay completes the current path from the battery to the main break coils, and the main break opens.

The reason for using the main break relay to control the break, instead of connecting the coils of the break itself into circuit of the function, is to insure the complete operation of the function before the opening of the main break.

THE SPACING CIRCUIT. The spacing circuit is shown in Fig. 89. This is the circuit utilized when a space signal is received over the line, usually between words. The spacing is performed in exactly

the same way as it is in the printing of letters, except that in this case, no printing action accompanies the spacing movement. As is indicated in the figure, the circuit receives current from the distributing circuit at the third back contact of P-5. From this point, the current path leads through the space coils, through the second back contact of the print relay, through the coils of the shift release relay, then through the main break relay to ground. Hence, when the space signal is received, upon the closing of the drum switch, the space coils, shift release, and relay coils are energized simultaneously. The remainder of the main break circuit is the same as that just described. It might be added that the print relay is in its inoperative position, since there is no rotation of the typewheel. Note that the space

tion of the typewheel. Note that the space operative position, since there is no rotabe added that the print relay in the intake the same as that just described. It might The remainder of the main break circuit is and relay coils are energized simultaneously, drum switch, the space coils, shift release, signal is received, upon the closing of the break relay to ground. Hence, when the space shift release relay, then through the main of the print relay, through the coils of the space coils, through the second back contact point, the current path leads through the at the third back contact of T-S. From this ceives current I on the distributing circuit is indicated in the figure, the circuit rection accompanies the spacing movement. As tere, except that in this case, no printing the same way as it is in the printing of let-

signal not only causes a spacing action, but also releases the carriage from the shift position, providing, of course, that the carriage was in that position.

THE LINING CIRCUIT. The circuit of the lining magnet is shown in Fig. 60. The battery current is received from the distributing circuit at the second front contact of P-5. From this point, the current path leads through the lining magnet, through the coils of the main break relay, and thence to ground. The main break and relay circuit is the same as the one previously described.

THE BACKING CIRCUIT. The circuit of the backing magnet is shown in Fig. 61. The circuit receives energy at the fourth front contact of P-5. From this point, the circuit leads to ground through the coils of the backing, release, and main break mag-

THE NOR-RUN SYSTEM OF SIGNALING TELEGRAPHY

of the backing, release, and main break mag-
the circuit leads to ground through the coils
fourth front contact of K-B. From this point,
fig. 61. The circuit receives energy at the
circuit of the backing magnet is shown in

THE BACKING CIRCUIT. The

is the same as the one previously described.
to ground. The main break and relay circuit
the coils of the main break relay, and thence
path leads through the lining magnet, through
test of K-B. From this point, the current
distributing circuit at the second front con-
60. The battery current is received from the

unit of the lining magnet is shown in Fig.

THE LINING CIRCUIT. The cir-

cuit not only causes a spacing section, but
also releases the carriage from the shift
position, providing, of course, that the car-
riage was in that position.

nets. Hence, the release (shift) and main break coils receive current simultaneously with the backing coils. The control of the main break through a relay is not necessary in the case of the backing mechanism, since only a momentary energizing of the backing coils is necessary: the mechanical lock on the backer holds the parts in the operative position after they have once been placed there by the backing magnet. Hence, the main break is placed directly in series with the backer coils.

THE SHIFT CIRCUITS. Next in the order of treatment comes the circuit of the shift magnets. However, there are some special requirements of this circuit which should be explained before the discussion of the circuit itself is begun.

The first requirement of the

THE MORE-RUN SYSTEM OF LIGHTING RECONSIDERED

main break through a relay is not necessary with the breaking coils. The control of the break coils receive current simultaneously from. hence, the release (shift) and main

in the case of the bearing mechanism, since only a momentary energizing of the breaking coils is necessary: the mechanical lock on the breaker holds the parts in the operative position after they have once been placed there by the breaking magnet. Hence, the main break is placed directly in series with the breaker coils.

THE SHIFT CIRCUITS. Next

of the shift magnets. However, there are some special requirements of this circuit which should be explained before the discussion of the circuit itself is begun.

The first requirement of the

shift magnets is, of course, that they normally carry no current, and that they remain in that condition until a shift signal is received. Upon the reception of this signal, the shift magnets should operate the shift mechanism and clear the printer by opening the main break. So far, the action is just the same as the other functions. However, the shift magnet should lock itself in position, so as not to be de-energized until a release signal is received from the transmitting station. In other words, the locking current must not come through the main break, but must come through the contacts of the release magnets. These requirements are fulfilled by the shift circuit.

The shift circuit is presented in Fig. 62, which shows the apparatus in its normal, or inoperative, position. The circuit receives current through the distrib-

circuit receives current through the distributor normal, or inoperative, position. The circuit is presented in Fig. 62, which shows the apparatus in the circuit condition until a shift signal is received. Upon the reception of this signal, the shift magnets should operate the shift mechanism and clear the printer by opening the main break. So far, the action is just the same as the other functions. However, the shift magnet should lock itself in position, so as not to be de-energized until a release signal is received from the transmitting station. In other words, the locking current must not come through the main break, but must come through the contacts of the release magnets. These requirements are fulfilled by the shift circuit.

The shift circuit is presented in Fig. 62, which shows the apparatus in the normal, or inoperative, position. The shift magnets in, of course, that they normally carry no current, and that they remain

uting circuit, being connected to that circuit at the second back point of P-5. From here, the current path leads through the left back contact of the shift relay, and then through the relay coils to ground. The relay also acts as the operating solenoid for the shift mechanism. While the shift relay is operating, it first closes its second front contact, and then opens the first back contact; this latter opening cuts the relay coils off from the distributing circuit. However, the closing of the second front contact completes a second current path to the battery, this path leading through the back contact of the release relay. Hence, the shift relay has operated and locked itself in the operative position.

At the same time, the relay has closed its first front contact, which

ting circuit, being connected to that circuit at the second back point of E. From here, the current path leads through the left back contact of the shift relay, and then through the relay coils to ground. The relay also acts as the operating solenoid for the shift mechanism. While the shift relay is operating, it first closes its second front contact, and then opens the first back contact; this latter opening cuts the relay coils off from the distributing circuit. However, the closing of the second front contact completes a second current path to the battery, this path leading through the back contact of the release relay. Hence, the shift relay has operated and locked itself in the operative position.

At the same time, the relay has closed its first front contact, which

closing supplies current to the main break magnet. The break therefore opens and clears the printer. However, the opening of the main break does not open the locking circuit of the shift relay; hence, that relay remains energized, and holds the typewheel in its shift position.

The release of the shift relay is effected by the operation of the release relay. This relay becomes energized when a spacing or backing signal is received over the line.

THE RUB-OUT CIRCUIT. The rub-out circuit is shown in Fig. 63. The battery is connected, through the distributor circuit, to the fourth back point of P-5. From here, the circuit leads through the main break resistance and main break coils to ground. Hence, when a rub-out signal is received, it operates the main break, and thereby clears the

THE MONROE SYSTEM OF PRINTING TELEGRAPHY

clearing supplies current to the main break magnet. The break therefore opens and clears the printer. However, the opening of the main break does not open the locking circuit of the shift relay; hence, that relay remains energized, and holds the typewheel in the shift position.

The release of the shift relay is effected by the operation of the release relay. This relay becomes energized when a spacing or backing signal is received over the line.

THE RUN-OUT CIRCUIT. The run-out circuit is shown in Fig. 63. The battery is connected, through the distributor circuit, to the fourth bank point of I-S. From here, the circuit leads through the main break relay and main break coils to ground. Hence, when a run-out signal is received, it operates the main break, and thereby clears the

printer.

THE DISTRIBUTING CIRCUIT.

Having completed the circuits of the individual functions, we will now study the distributor system by which these circuits are connected to the battery. The complete distributor circuit is presented in Fig. 64. It is here shown in the inoperative condition, which condition it retains if a rub-out signal is received; any other signal changes the connections. That part of the circuit directly concerned with the printing of characters has already been discussed; we are now concerned with the circuit from the standpoint of the purely operating functions.

There are two requirements of the distributor circuit in this connection, viz., first, it must connect the battery to the beginning of the individual circuits, and second, it must never connect the

THE MORSE SYSTEM OF PRINTING TELEGRAPHY

printer.

THE DISTRIBUTING CIRCUIT.

Having completed the circuits of the individual functions, we will now study the distributor system by which these circuits are connected to the battery. The complete distributor circuit is presented in fig. 64. It is here shown in the inoperative condition,which condition it retains if a current signal is received; any other signal changes the connections. That part of the circuit directly concerned with the printing of characters has already been discussed; we are now concerned with the circuit from the standpoint of the purely operating functions.

There are two requirements of the distributor circuit in this connection, viz., first, it must connect the battery to the beginning of the individual circuits, and second, it must never connect the

battery to the rotator circuits upon the reception of an operating signal. If the rotator and center-letter circuits do not carry current, the print relay will not operate, and there will be no printing action on the part of the machine.

The following table shows what combinations of current pulses allow of these requirements.

P-3	P-2	P-1	P-4	P-5
+	+	+	+	±
+	+	—	+	±
+	+	+	—	±

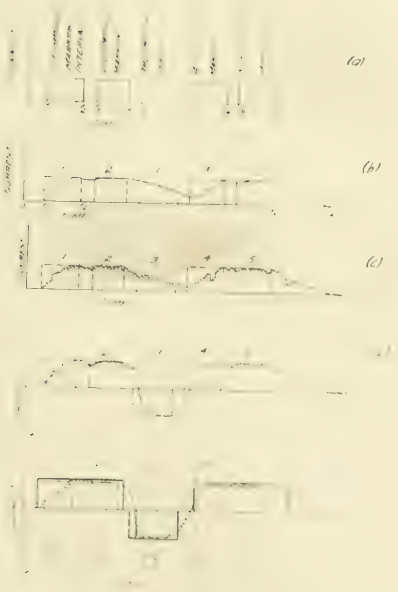
An examination of the code shows that every operating signal comes under one of these classifications.

battery to the rotator circuits upon the reception of an operating signal. If the rotator and center-letter circuits do not carry current, the print relay will not operate, and there will be no printing action on the part of the machine.

The following table shows what combinations of current pulses allow of these requirements.

P-3	P-2	P-1	P-4	P-5

An examination of the code shows that every operating signal comes under one of these classifications.



Impulse Diagram.

Plate I - Perforator.

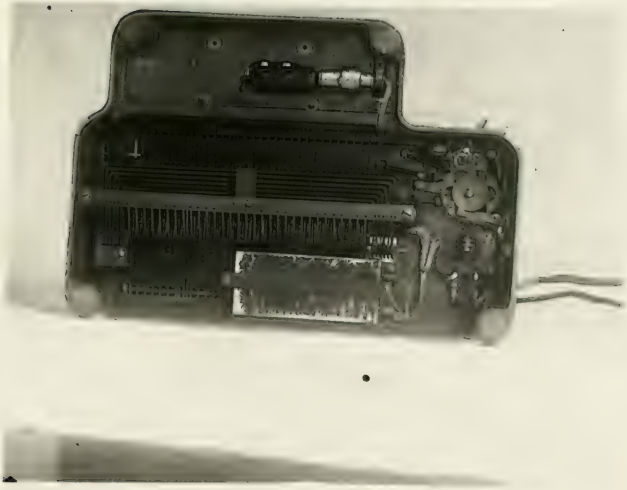


Plate II - Perforator.

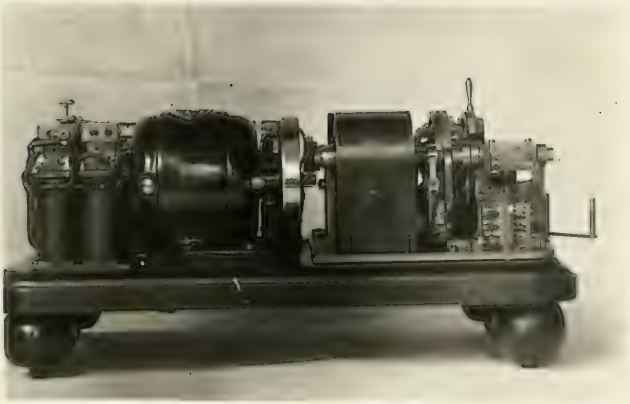


Plate III - Distributor

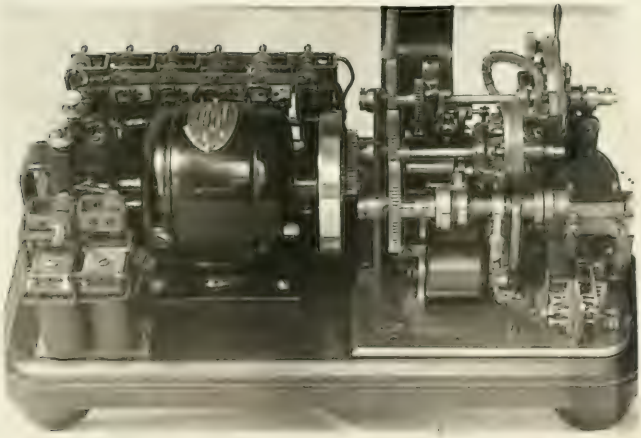


Plate IV - Distributor.

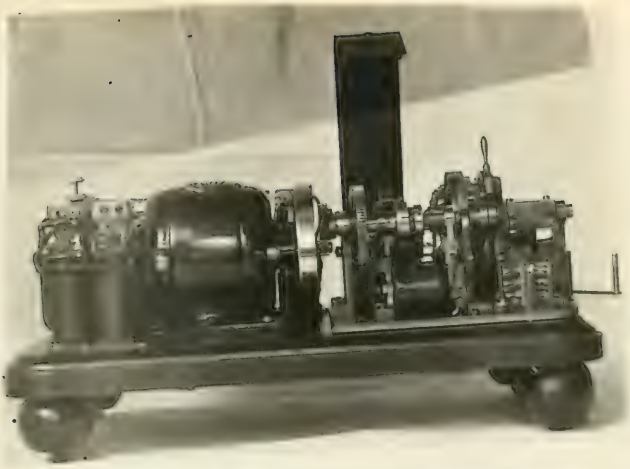


Plate V - Distributor.

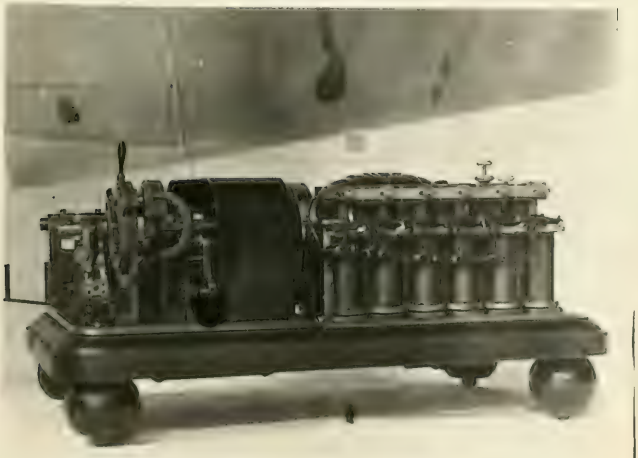


Plate VI - Distributor.

Plate - VII - Wheatstone Differential Relay.

Plate VIII - Wheatstone Differential Relay.

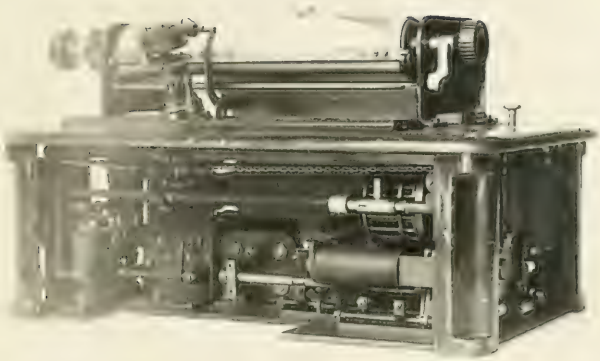


Plate IX - Printer.

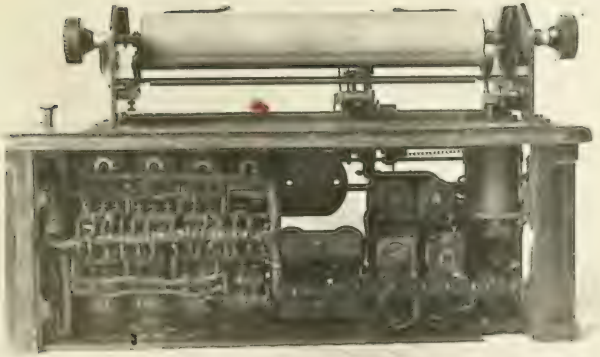


Plate X - Printer.

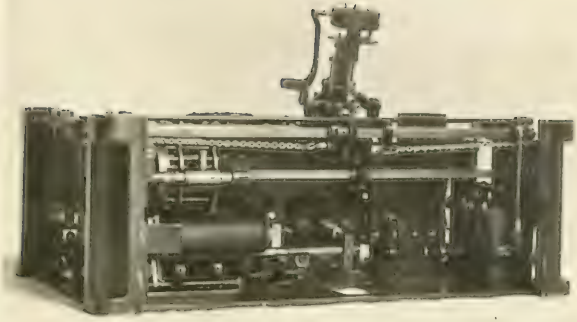


Plate XI - The Printer.

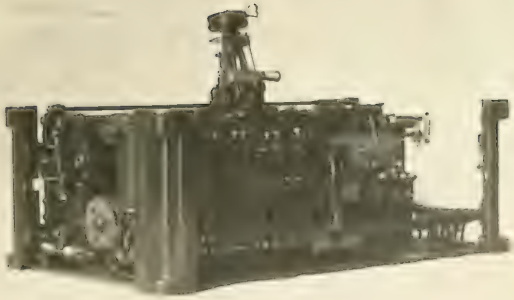


Plate XII - The Printer.

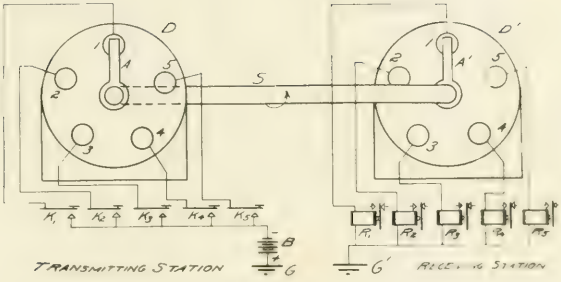

D
D'
1
2
3
4
5
A
A'
S
K1
K2
K3
K4
K5
B
G
G'
R1
R2
R3
R4
R5
TRANSMITTING STATION
RECEIVING STATION

FIG. 1.

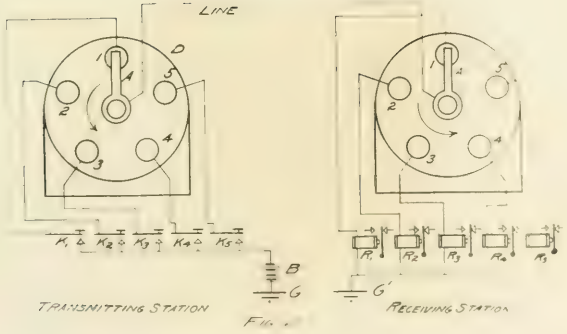

LINE
D
1
2
3
4
5
K1
K2
K3
K4
K5
B
G
G'
R1
R2
R3
R4
R5
TRANSMITTING STATION
RECEIVING STATION

FIG. 2.

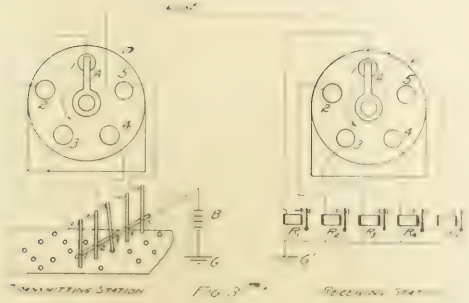


FIG. 3.

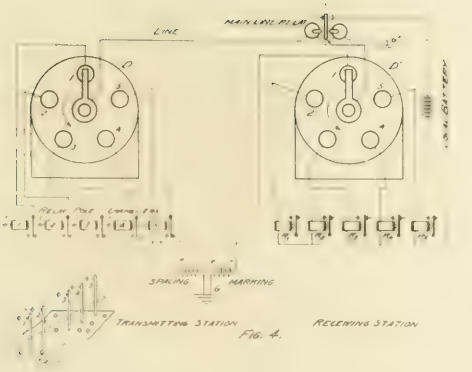


FIG. 4.

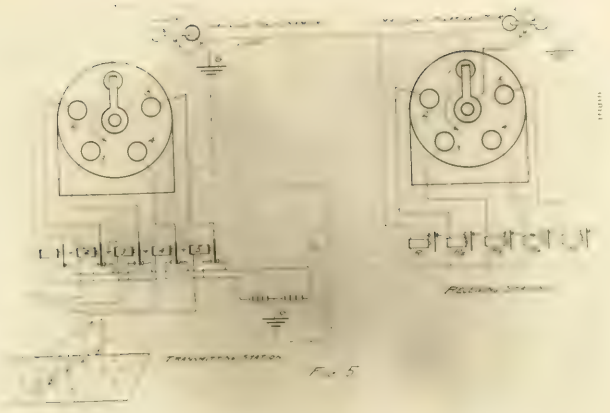


Fig. 5

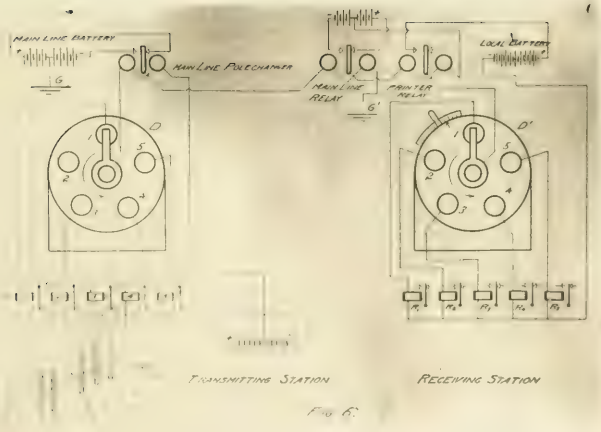

MAIN LINE BATTERY
MAIN LINE POLECHANGER
MAIN LINE RELAY
PRINTER RELAY
LOCAL BATTERY
TRANSMITTING STATION
RECEIVING STATION

Fig. 6.

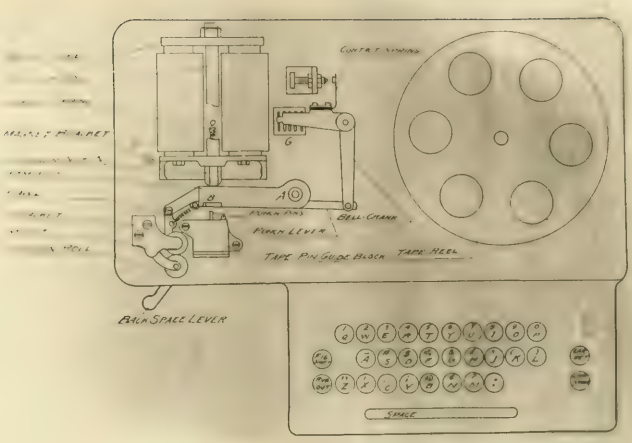

CONTACT SPRING
G
B
A
PUNCH PINS
BELL CRANK
PUNCH LEVER
TAPE PIN GUIDE BLOCK
TAPE HEEL
BACK SPACE LEVER
SPACE

FIG. 7.

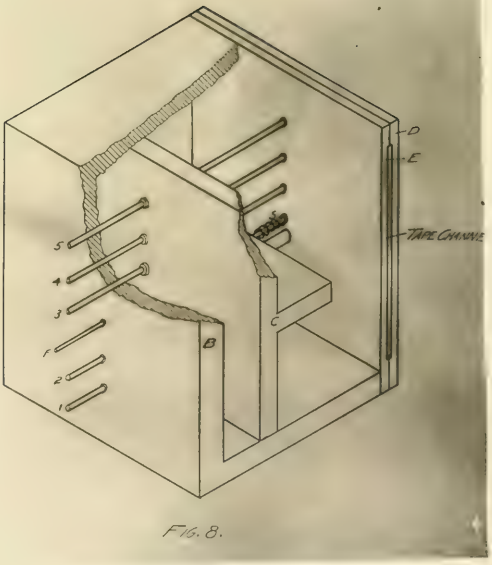
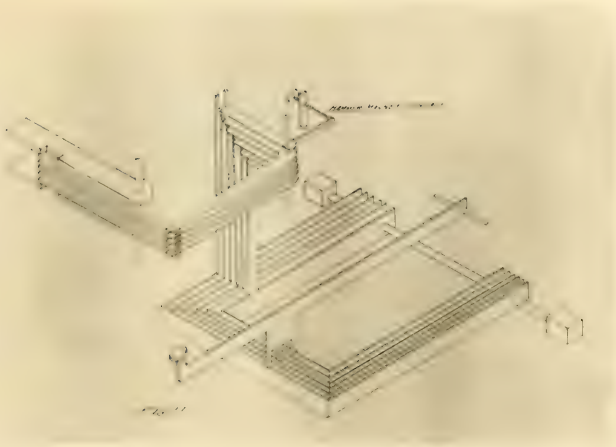

D
E
TAPE CHANNEL
5
4
3
F
2
1
B
C

FIG. 8.



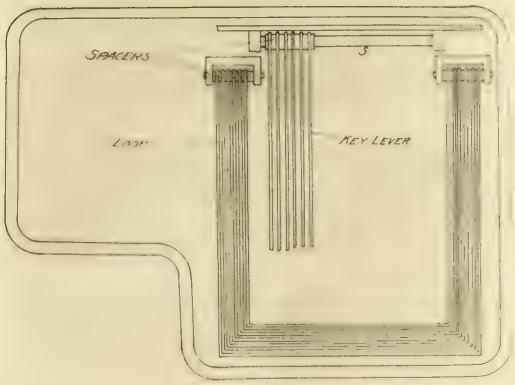


FIG. 12

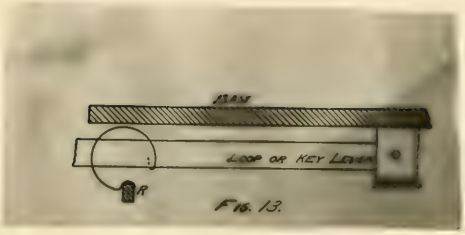
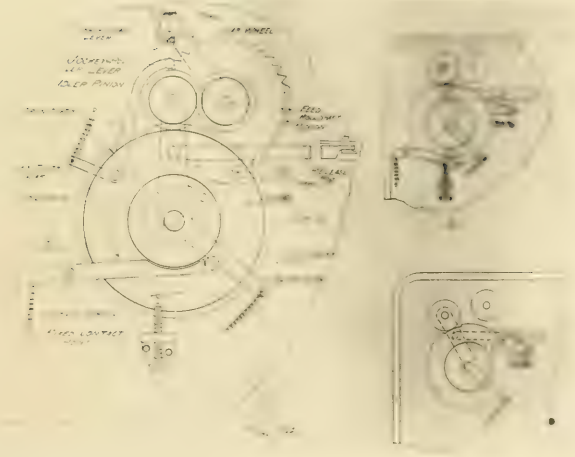
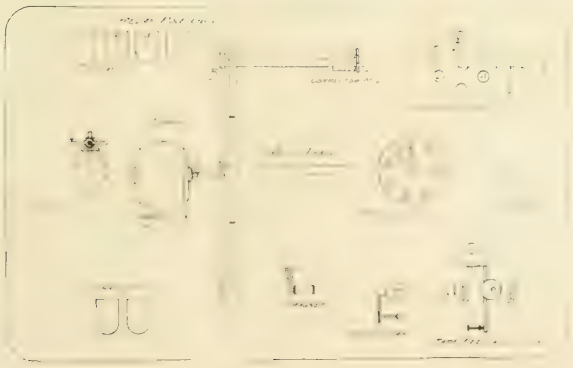


Fig. 13.





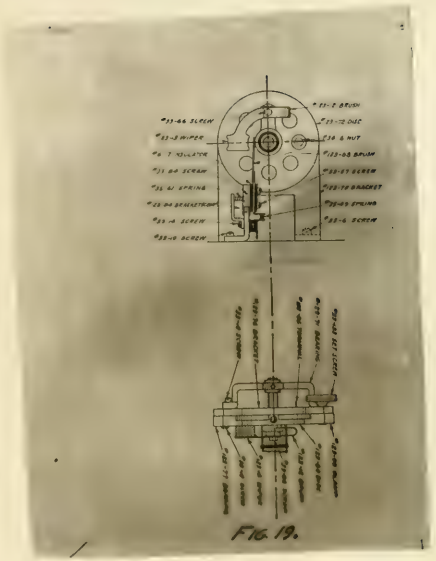


FIG. 19.

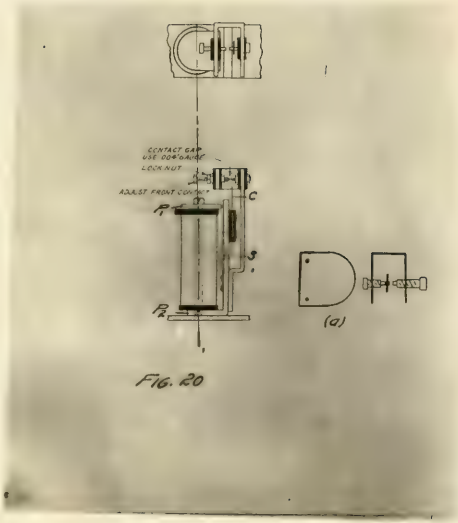

CONTACT GAP
USE .004 GAUGE
LOCK NUT
ADJUST FRONT CONTACT
C
P1
S
P2
(a)

FIG. 20

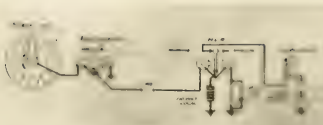


FIG. 21.

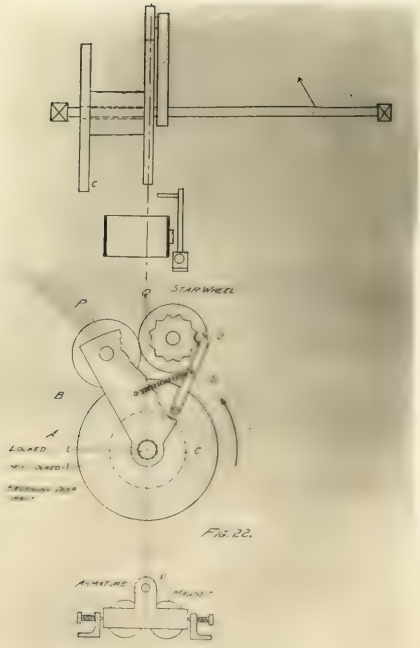


FIG. 22.

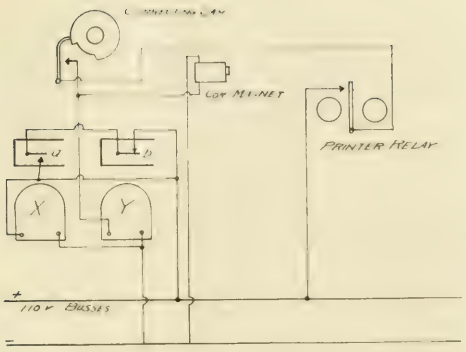
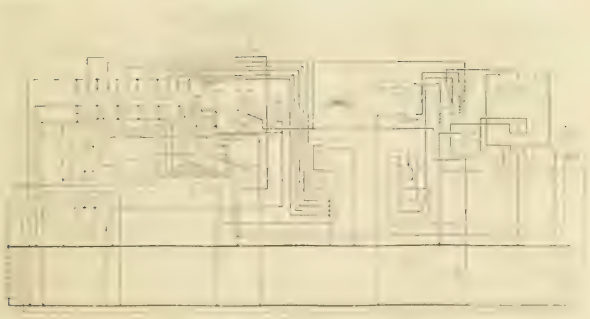


FIG. 23.



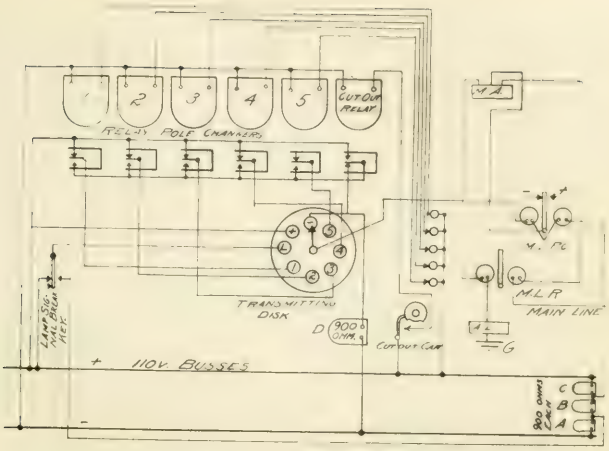
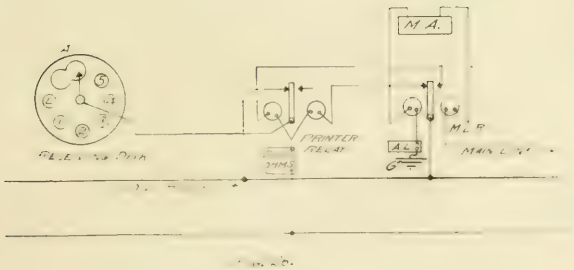

1
2
3
4
5
CUT OUT RELAY
RELAY POLE CHANGERS
M A
M. P.
M L R
MAIN LINE
TRANSMITTING DISK
D
900 OHMS
CUT OUT COIL
G
110 V BUSSES
+
-
200 OHMS
C
B
A

FIG. 25.


M A.
M L R
MAIN LINE
PRINTER RELAY
G

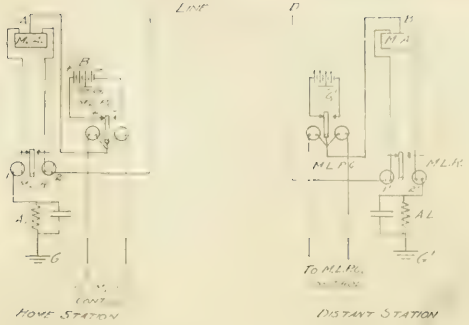


FIG. 27.

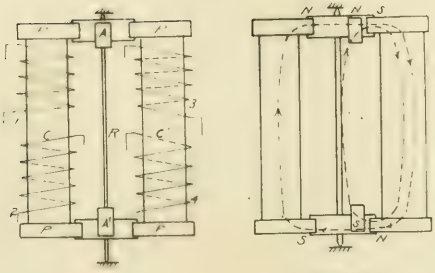


FIG. 29.

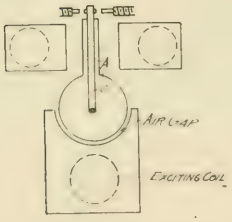


FIG. 28.

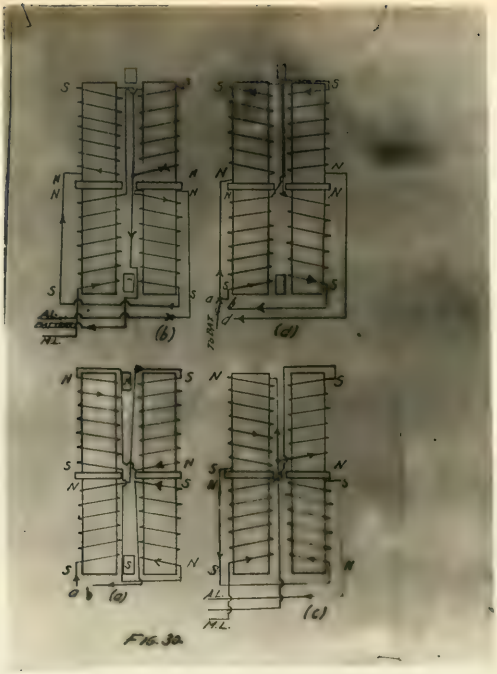


FIG. 30.

FIG. 31.

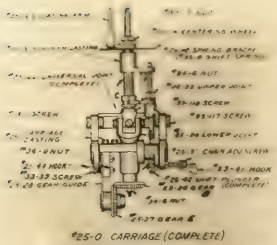


FIG. 32.

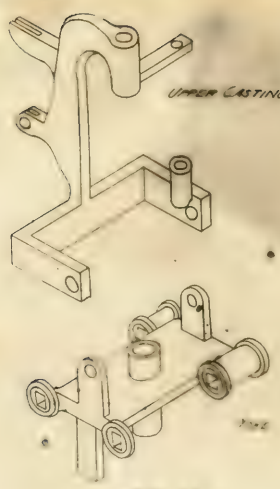
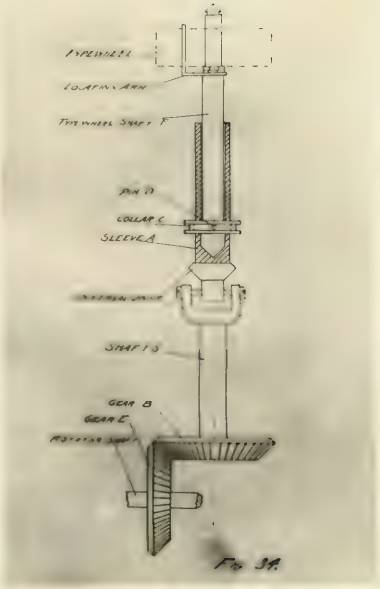


FIG. 33.


TYPEWHEEL
LOCATING ARM
TYPEWHEEL SHAFT F
PIN D
COLLAR C
SLEEVE A
SHAFT B
GEAR B
GEAR C
Fig. 34.

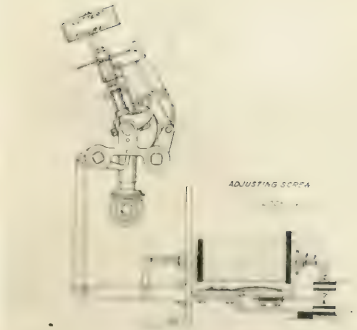
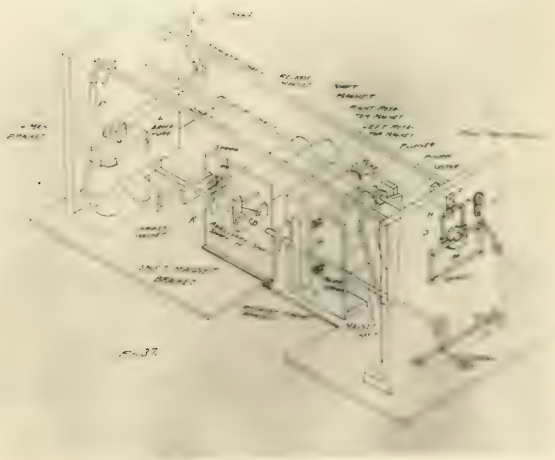

ADJUSTING SCREW
Fig. 35.

FIG. 36.



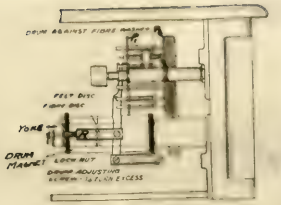


FIG. 38

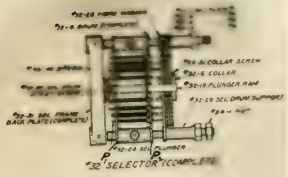


FIG. 39

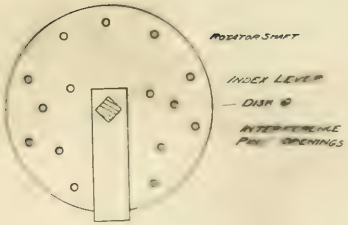
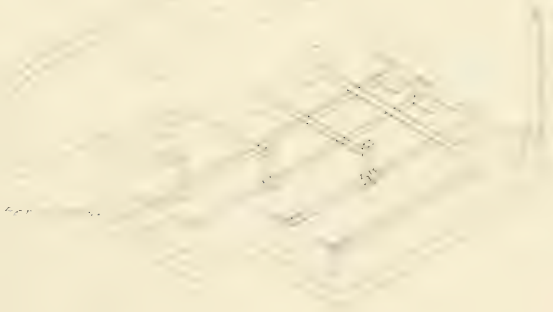
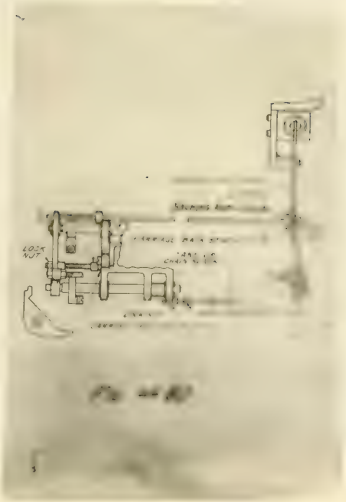
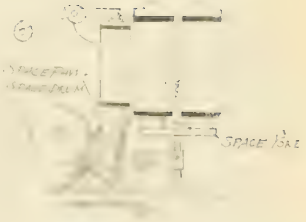


FIG. 40.

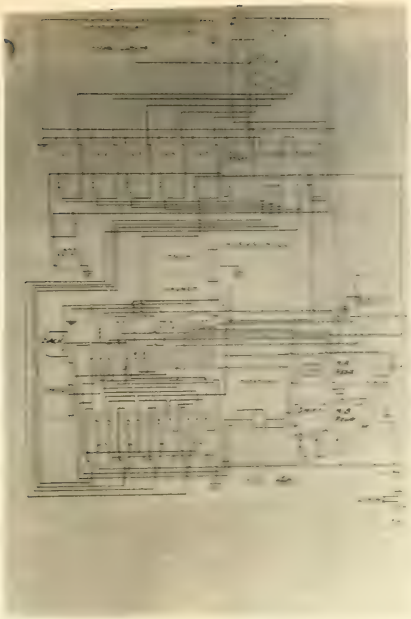






(c)

FIG. 44(b) & (c)



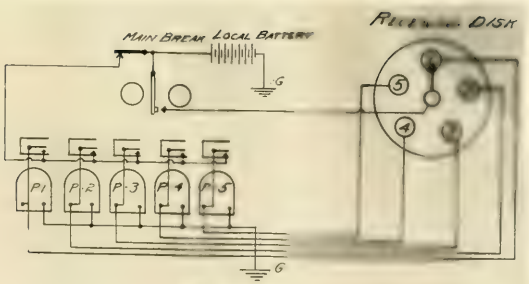
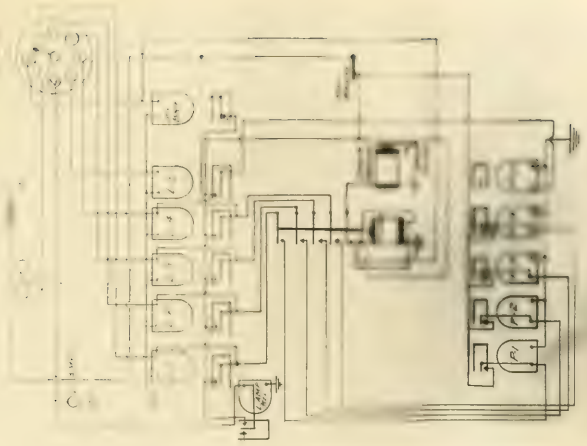


Fig. 47.



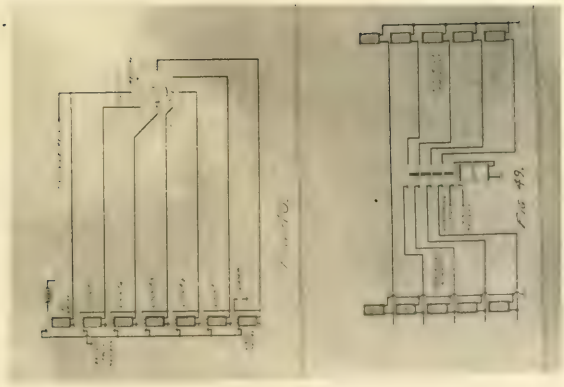


FIG 49.

FIG. 51.

HOLD TYPEWHEEL AGAINST PLATEN
ADJUSTING SCREW
MAIN SPACE PLUNGER
LOCK NUT

FIG. 52.

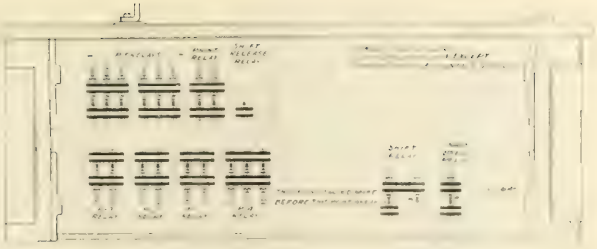


FIG 53.

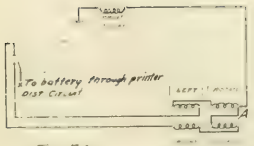


FIG. 54.

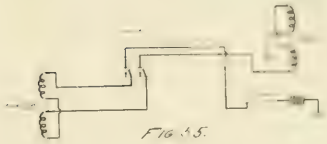


FIG. 55.

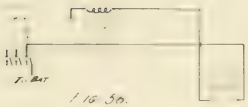
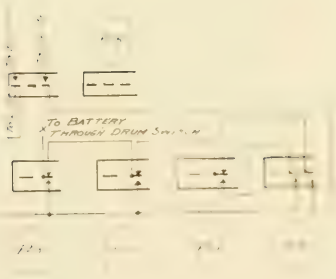
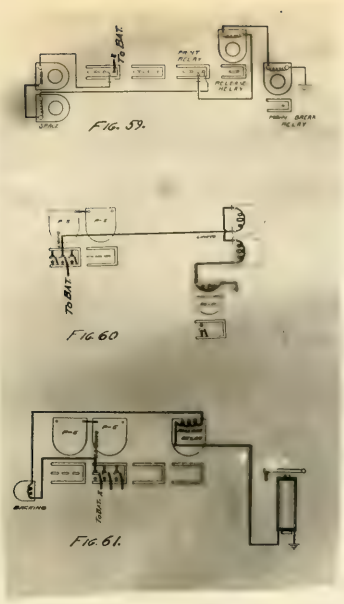


FIG 56.


To Battery
Through Drum Switch


To Bat.
Fig. 59.
To Bat.
Fig. 60
To Bat.
Fig. 61.

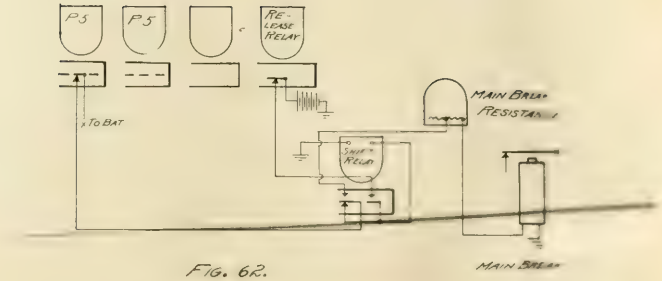

P3
P5
Re-
lease
Relay
To Bat
Main Brea
Resistan
Main Brea

Fig. 62.

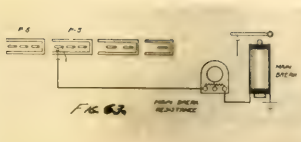


FIG. 63.

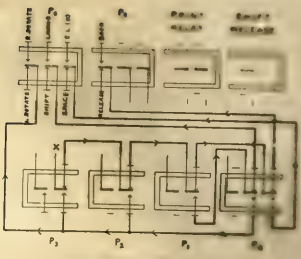


FIG. 64.